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FINAL SAMPLING AND ANALYSIS PLAN FIELD SAMPLING PLAN AND QUALITY ASSURANCE PROJECT PLAN FOR MUNITIONS RESPONSE REMEDIAL INVESTIGATION AT UNEXPLODED ORDNANCE SITE UXO-22 FORMER MUNITIONS DEPOT MCB CAMP LEJEUNE NC

8/1/2013

CH2M HILL

Final

Sampling and Analysis Plan
Field Sampling Plan and Quality Assurance Project Plan for Munitions Response Remedial Investigation at Site UXO-22 – Former Munitions Disposal Area

Marine Corps Installations East—Marine Corps Base Camp Lejeune, North Carolina

Contract Task Order WE54

August 2013

Prepared for

Department of the Navy
Naval Facilities Engineering Command
Mid-Atlantic

Under the

NAVFAC CLEAN 8012 Program
Contract N62470-11-D-8012

Prepared by

CH2MHILL

Charlotte, North Carolina

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QAPP Worksheet #1—Title and Approval Page

Final

**Sampling and Analysis Plan (Field Sampling Plan and Quality Assurance Project Plan)
for Munitions Response Remedial Investigation at
Site UXO-22 – Former Munitions Disposal Area
August 2013**

**Marine Corps Installations East—Marine Corps Base Camp Lejeune (MCIEAST-MCB CAMLEJ)
Jacksonville, North Carolina**

**Prepared for:
Department of the Navy
Naval Facilities Engineering Command
Mid-Atlantic Division**

**Prepared by:
CH2M HILL
11301 Carmel Commons Blvd
Charlotte, North Carolina 28226**

**Prepared under:
NAVFAC CLEAN 8012 Program
Contract No. N62470-11-D-8012
Contract Task Order WE54**

QA Review:

Dan Hockett 8-8-13

Daniel Hockett
CH2M HILL Project Manager / Date

Jessica Skeean 8/8/13

Jessica Skeean
CH2M HILL Activity Quality Manager / Date

Other Approvals:

Navy Munitions Response Program Quality Assurance Officer / Date

Dave Cleland
Navy Remedial Project Manager / Date

8/21/2013
Gena Townsend
USEPA Project Manager / Date

8/21/2013
Randy McElveen
NCDENR Project Manager / Date

Executive Summary

This Quality Assurance Project Plan (QAPP) supports the munitions response (MR) activities being performed for the Remedial Investigation (RI) at Munitions Response Site (MRS) Site Unexploded Ordnance (UXO)-22, Former Munitions Disposal Area, located at Marine Corps Installations East - Marine Corps Base Camp Lejeune (MCIEAST-MCB CAMLEJ), and serves as a guideline for the RI field activities and data quality assessment.

Site UXO-22 is located in the 'Mainside' portion of MCIEAST – MCB CAMLEJ within Operable Unit 2 (OU2), which consists of Installation Restoration (IR) Sites, 6, 82, and 9. Since 1983, numerous phases of environmental investigation have been performed at OU2. After material potentially presenting an explosive hazard (MPPEH) was discovered throughout OU2 during previous investigations, 75 acres of OU2 were identified and designated as UXO-22. In 2010, Site UXO-22 was added to the Munitions Response Program (MRP). Site UXO-22 has historically been used for disposal of waste material such as undocumented MPPEH, wood, metal, batteries, communication wire, drums, paint containers, grease containers, pesticides, transformers containing polychlorinated biphenyls (PCBs), solvents, and waste oil. Site UXO-22 consists of partially developed land that includes the former Defense Reutilization and Marketing Office (DRMO), Storage Lots 201 and 203.

A Preliminary Assessment/Site Inspection (PA/SI) at Site UXO-22 was completed in 2012 (CH2M HILL, 2012d). Based on the results of the PA/SI and the presence of munitions of explosive concern (MEC) and MPPEH identified within the MRS during previous investigations, the site is proceeding to the next phase of the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) process, Remedial Investigation (RI)/Feasibility Study. The RI will involve digital geophysical mapping (DGM) and intrusive investigation performed across 10 percent of the MRS. The purpose of the RI is to characterize the nature and extent of MEC/MPPEH across the site. This QAPP is intended to be the primary work-planning document for the RI activities being performed at Site UXO-22. Additional documents such as the Technical Management Plan (TMP), Geophysical Investigation Plan (GIP), and a Geophysical System Verification (GSV) Plan are included as appendices to this QAPP. The Health and Safety Plan (HSP), which provides an interface with CH2M HILL's overall health and safety (H&S) program, is being prepared as a separate document. This QAPP is being developed in accordance with the following guidance documents:

- *EPA Guidance for Quality Assurance Project Plans* (United States Environmental Protection Agency [USEPA], 2002)
- *Uniform Federal Policy for Quality Assurance Project Plans: Evaluating, Assessing, and Documenting Environmental Data Collection and Use Programs* (USEPA, 2005)

This document consists of 37 worksheets, which are based upon the September 2009 MEC UFP-QAPP format. Worksheets that are not applicable to this QAPP format have been designated as "Not Applicable." All tables are embedded within the worksheets, and figures are included at the end of worksheets, where applicable.

The Department of the Navy (Navy), Naval Facilities Engineering Command (NAVFAC), Mid-Atlantic Division, is conducting this RI in accordance with the CERCLA investigation process. This QAPP is being submitted to the MCIEAST-MCB CAMLEJ Environmental Restoration Partnering Team, which consists of representatives from NAVFAC Mid-Atlantic, MCIEAST-MCB CAMLEJ, USEPA Region 4, and North Carolina Department of Environment and Natural Resources (NCDENR). This QAPP will help ensure that data collected or compiled are scientifically sound, of known and documented quality, and suitable for intended uses.

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QAPP Worksheets

Appendixes

Figures

Abbreviations and Acronyms

3R	Recognize, Retreat, Report
AM	Activity Manager
AQM	Activity Quality Manager
Baker	Baker Environmental, Inc.
bgs	below ground surface
BIP	blow-in-place
CA	corrective action
CAS	Chemical Abstract Service
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CLEAN	Comprehensive Long-term Environmental Action—Navy
CSM	conceptual site model
DDT	dichlorodiphenyldichloroethane
DFOW	definable feature of work
DGM	digital geophysical mapping
DQI	data quality indicator
DRMO	Defense Reutilization and Marketing Office
ECP	Environmental Condition of Property
EMD	Environmental Management Division
EME	earth-moving equipment
EOD	explosive ordnance disposal
ERA	Ecological Risk Assessment
ESS	Explosives Safety Submission
FP	Follow-up Phase
FS	Feasibility Study
FTL	Field Team Leader
FTP	file transfer protocol
GIP	Geophysical Investigation Plan
GIS	geographic information system
GPS	global positioning system
GSV	Geophysical System Verification
H&S	Health and Safety
HEAT	high-explosive anti-tank
HHRA	Human Health Risk Assessment
HSO	Health and Safety Officer
HSP	Health and Safety Plan
IAW	in accordance with
ID	Identification
IP	Initial Phase
IR	Installation Restoration
LCS	laboratory control sample
LTM	long-term monitoring
LUC	land use control

MC	munitions constituents
MCIEAST-MCB CAMLEJ	Marine Corps Installations East – Marine Corps Base Camp Lejeune
MCL	maximum contaminant level
MDAS	material documented as safe
MDL	method detection limit
MEC	munitions and explosives of concern
µg/L	microgram per liter
mm	millimeter
MPPEH	material potentially presenting an explosive hazard
MR	munitions response
MRP	Munitions Response Program
MRS	Munitions Response Site
MS/MSD	matrix spike/matrix spike duplicate
MQO	measurement quality objective
mV	millivolt
NAVFAC	Naval Facilities Engineering Command
Navy	Department of the Navy
NCDENR	North Carolina Department of Environment and Natural Resources
NIRIS	Naval Installation Restoration Information Solution
nT	nanotesla
NTCRA	Non-time-critical Removal Action
NTR	Navy Technical Representative
OHM	OHM Remediation Services Corporation
ORR	Operations Readiness Review
OU	operable unit
PA	Preliminary Assessment
PAL	project action limit
PCB	polychlorinated biphenyl
PM	Project Manager
POC	point of contact
PP	Preparatory Phase
PQL	practical quantitation limit
PQO	project quality objective
QA	quality assurance
QAMS	Quality Assurance Management System
QAO	Quality Assurance Officer
QAPP	Quality Assurance Project Plan
QC	quality control
QCS	Quality Control Specialist
QL	quantitation level
Rhea	Rhea Engineers and Consultants, Inc.
RI	Remedial Investigation
RPM	Remedial Project Manager
RSL	Regional Screening Level
SAP	Sampling and Analysis Plan
SI	Site Investigation
SME	subject-matter expert

SOP	standard operating procedure
SSC	Site Safety Coordinator
SSHSP	Site-specific Health and Safety Plan
STC	Senior Technical Consultant
SUXOS	Senior Unexploded Ordnance Supervisor
TBD	to be determined
TM	Task Manager
TMP	Technical Management Plan
USEPA	United States Environmental Protection Agency
UXO	unexploded ordnance
UXOQCS	Unexploded Ordnance Quality Control Specialist
UXOSO	Unexploded Ordnance Safety Officer
VOC	volatile organic compound

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QAPP Worksheet #2—QAPP Identifying Information

Site Name/Number: UXO-22 – Former Munitions Disposal Area

Operable Unit: OU2

Contractor Name: CH2M HILL

Contract Number: N62470-11-D-8012, Contract Task Order WE54

Contract Title: Comprehensive Long-term Environmental Action—Navy (CLEAN) 8012

1. This Quality Assurance Project Plan (QAPP) was prepared in accordance with the requirements of the following documents:
   - *EPA Guidance for Quality Assurance Project Plans* (United States Environmental Protection Agency [USEPA], 2002)
   - *Uniform Federal Policy for Quality Assurance Project Plans: Evaluating, Assessing, and Documenting Environmental Data Collection and Use Programs* (USEPA, 2005)
2. Identify regulatory program:
   - Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA)
3. This is a project-specific QAPP for a munitions response (MR) investigation.
4. List dates of scoping sessions that were held:

Scoping Session	Date
Partnering Team Scoping Session – MR Investigation Approach	September 12, 2012

5. List dates and titles of any Sampling and Analysis Plan (SAP) documents written for previous site work that are relevant to the current investigation.

Title	Author/Date
Site-specific Work Plan Addendum for Intrusive Investigation Activities at UXO-22 Marine Corps Base Camp Lejeune, Jacksonville, North Carolina	CH2M HILL, August 2010a
Sampling and Analysis Plan (Field Sampling Plan and Quality Assurance Project Plan) Preliminary Assessment/Site Inspection; Military Munitions Response Program Site UXO-22 – Former Munitions Disposal Area, Marine Corps Installations East - Marine Corps Base Camp Lejeune, North Carolina. March.	CH2M HILL, March 2012a

6. List organizational partners (stakeholders) and connection with lead organization:
   - Department of the Navy (Navy) – Naval Facilities Engineering Command (NAVFAC) (lead organization)
   - Marine Corps Installations East – Marine Corps Base Camp Lejeune (MCIEAST-MCB CAMLEJ) (facility)
   - USEPA Region 4 (regulatory stakeholder)
   - North Carolina Department of Environment and Natural Resources (NCDENR) (regulatory stakeholder)

QAPP Worksheet #2—QAPP Identifying Information (continued)

1. If any required QAPP elements or required information are not applicable to the project or are provided elsewhere, then note the omitted QAPP elements and provide an explanation for their exclusion.

   Worksheets #15, #19, #20, #23-28, #30, and **#36** are not applicable to this QAPP. These worksheets pertain to environmental sampling and analytical laboratory requirements that are not included as part of this MR investigation and have been designated as "Not Applicable" in the document.

QAPP Worksheet #	Required Information	Included or Excluded
A. Project Management		
Documentation		
1	Title and Approval Page	**Included**
2	Table of Contents QAPP Identifying Information	**Included**
3	Distribution List	**Included**
4	Project Personnel Sign-Off Sheet	**Included**
Project Organization		
5	Project Organizational Chart	**Included**
6	Communication Pathways	**Included**
7	Personnel Responsibilities and Qualifications Table	**Included**
8	Special Personnel Training Requirements Table	**Included**
Project Planning/Problem Definition		
9	Project Planning Session Documentation (including Data Needs tables) Project Scoping Session Participants Sheet	**Included**
10	Conceptual Site Model, Site History, and Background. Site Maps (historical and present)	**Included**
11	Problem Definition and Site-Specific Project Quality Objectives (PQOs)	**Included**
12	Measurement Performance Criteria Table	**Included**
13	Sources of Secondary Use Data and Information Secondary Use of Data Criteria and Limitations Table	**Included**
14	Summary of Project Tasks	**Included**
15	Reference Limits and Evaluation Table	**Excluded**
16	Project Schedule/Timeline Table	**Included**
B. Measurement Data Acquisition		
Sampling Tasks		
17	Sampling Design and Rationale	**Included**
18	Sampling Locations and Methods/ Standard Operating Procedure (SOP) Requirements Table Sample Location Map(s)	**Included**
19	Analytical Methods/SOP Requirements Table	**Excluded**
20	Field Quality Control (QC) Sample Summary Table	**Excluded**
21	Project Sampling SOP References Table Sampling SOPs	**Included**
22	Field Equipment Calibration, Maintenance, Testing, and Inspection Table	**Included**

QAPP Worksheet #	Required Information	Included or Excluded
Analytical Tasks		
23	Analytical SOPs Analytical SOP References Table	**Excluded**
24	Analytical Instrument Calibration Table	**Excluded**
25	Analytical Instrument and Equipment Maintenance, Testing, and Inspection Table	**Excluded**
Sample Collection		
26	Sample Handling System, Documentation Collection, Tracking, Archiving, and Disposal Sample Handling Flow Diagram	**Excluded**
27	Sample Custody Requirements, Procedures/SOPs Sample Container Identification (ID) Example Chain-of-Custody Form and Seal	**Excluded**
QC Samples		
28	QC Samples Table Screening/Confirmatory Analysis Decision Tree	**Excluded**
Data Management Tasks		
29	Project Documents and Records Table	**Included**
30	Analytical Services Table Analytical and Data Management SOPs	**Excluded**
C. Assessment Oversight		
31	Planned Project Assessments Table Audit Checklists	**Included**
32	Assessment Findings and Corrective Action (CA) Responses Table	**Included**
33	Quality Assurance (QA) Management Reports Table	**Included**
D. Data Review		
34	Verification (Step I) Process Table	**Included**
35	Validation (Steps IIa and IIb) Process Table	**Included**
36	Validation (Steps IIa and IIb) Summary Table	**Excluded**
37	Usability Assessment	**Included**

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QAPP Worksheet #3—Distribution List

Name of QAPP Recipients	Title/Role	Organization	Telephone Number	E-mail Address or Mailing Address	Document Control Number
Dave Cleland	Navy Technical Representative (NTR)	NAVFAC Mid-Atlantic	(757) 322-4851	david.t.cleland@navy.mil	An administrative record number will be assigned when the final document is being prepared)
Mike Green	Munitions Response Program (MRP) Quality Assurance Officer (QAO)	NAVFAC Atlantic	(757) 322-8108	mike.green@navy.mil	
Charity Rychak	Base Environmental Management Division (EMD) Environmental Engineer	MCIEAST – MCB CAMLEJ	(910) 451-9385	charity.rychak@usmc.mil	
Gena Townsend	Remedial Project Manager (RPM)	USEPA	(404) 562-8538	townsend.gena@epa.gov	
Randy McElveen	NCDENR RPM	NCDENR	(919) 707-8341	randy.mcelveen@ncdenr.gov	
Matt Louth	Activity Manager (AM)	CH2M HILL	(757) 671-6240	matt.louth@CH2M.com	
Jessica Skeean	Activity Quality Manager (AQM)	CH2M HILL	(704) 543-3284	jessica.skeean@CH2M.com	
Dan Hockett	Project Manager (PM)	CH2M HILL	(704) 543-3264	daniel.hockett@CH2M.com	
Timothy Garretson	MRP Technical Lead	CH2M HILL	(904) 374-5633	timothy.garretson@CH2M.com	
Tom Roth	Senior Technical Consultant (STC)	CH2M HILL	(404) 474-7640	tom.roth@CH2M.com	
George DeMetropolis	MR Safety & Quality Control Officer	CH2M HILL	(619) 564-9627	george.demetropolis@ch2m.com	
Matt Barner	Project Geophysicist	CH2M HILL	(704) 543-3273	matthew.barner@CH2M.com	
David Lubell	Task Manager (TM)	CH2M HILL	(919) 760-1788	david.lubell@CH2M.com	
To be determined (TBD)	UXO Qualified Personnel	CH2M HILL	TBD	TBD	
TBD	Field Team Leader (FTL)/Site Safety Coordinator (SSC)	CH2M HILL	TBD	TBD	
Anita Dodson	Navy CLEAN Program Chemist	CH2M HILL	(757) 671-6218	anita.dodson@ch2m.com	

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QAPP Worksheet #4—Project Personnel Sign-Off Sheet

Name	Organization/Title/Role	Telephone Number (optional)	Signature/email Receipt	QAPP Section Reviewed	Date QAPP Read
Dave Cleland	Navy NTR	(757) 322-4851			
Charity Rychak	MCIEAST – MCB CAMLEJ/EMD Environmental Engineer	(910) 451-9385			
Matt Louth	CH2M HILL/Activity Manager	(757) 671-6240			
Jessica Skeean	CH2M HILL/Activity Quality Manager	(704) 543-3284			
Dan Hockett	CH2M HILL/PM	(704) 543-3264			
David Lubell	CH2M HILL/TM	(919) 760-1788			
Timothy Garretson	CH2M HILL/MRP Technical Lead	(904) 374-5633			
Matt Barner	CH2M HILL/Project Geophysicist	(704) 543-3273			
Tom Roth	CH2M HILL/STC	(404) 474-7640			
George DeMetropolis	CH2M HILL/MR Health and Safety (H&S) & Quality Officer	(619) 564-9627			
Carl Woods	CH2M HILL/H&S Officer (HSO)	(513) 889-5771			
Anita Dodson	CH2M HILL/Navy CLEAN Program Chemist	(757) 671-6218			
TBD	CH2M HILL/UXO Qualified Personnel	TBD			
TBD	CH2M HILL/FTL/SSC	TBD			
Geophysical Survey Subcontractor	TBD	TBD			
UXO Support Services	TBD	TBD			

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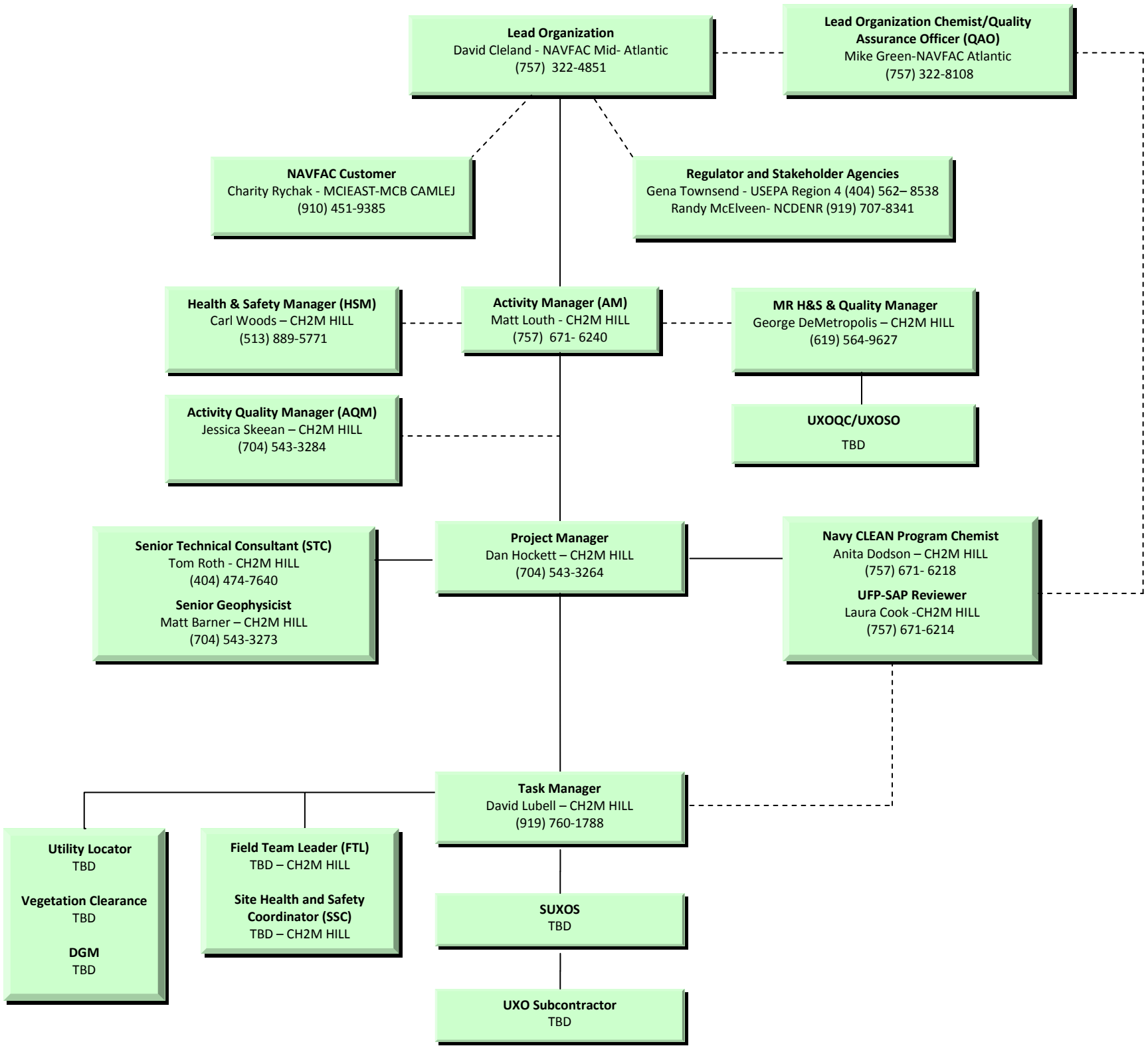
QAPP Worksheet #5—Project Organizational Chart



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QAPP Worksheet #6—Communication Pathways

Communication Drivers	Responsible Affiliation	Name	Phone Number and/or E-mail	Procedure
Communication with Navy (lead agency)	Navy NTR	Dave Cleland	(757) 322-4851	Primary point of contact (POC) for Navy; can delegate communication to other internal or external POCs. RPM will notify USEPA and NCDENR via email or telephone call within 24 hours for field changes effecting the scope or implementation of the design occur. Navy will have 30 days for work plan review. All field data will be presented and discussed during partnering meetings.
Communication with MCIEAST – MCB CAMLEJ	Base EMD	Charity Rychak	(910) 451-9385	Primary POC for the Base EMD; can delegate communication to other internal or external POCs. RPM will notify the Base EMD via e-mail or telephone call within 24 hours for field changes affecting the scope. All data results will be presented and discussed during partnering meetings
Communication with USEPA	USEPA RPM	Gena Townsend	(404) 562-8538	Primary POC for USEPA; can delegate communication to other internal or external POCs. Upon notification of field changes, USEPA will have 24 hours to approve or comment on the field changes. All data results will be presented and discussed during partnering meetings
Communication with NCDENR	NCDENR RPM	Randy McElveen	(919) 707-8341	Project POC for NCDENR; can delegate communication to other internal or external POCs. Upon notification of field changes, NCDENR will have 24 hours to approve or comment on the field changes.
Communication regarding overall project status and implementation and primary POC with Navy RPM, USEPA, and NCDENR	CH2M HILL AM	Matt Louth	(757) 671-6240	Oversees project and will be informed of project status by the PM. If field changes occur AM will work with the Navy RPM to communicate in field changes to the team via email within 24hrs. All data results will be communicated to the project team during the first partnering meeting following data receipt.
Quality issues during project implementation and data interpretation	CH2M HILL AQM	Jessica Skeean	(704) 543-3284	Contact the AQM regarding quality issues during project implementation. The AQM will report to the AM and the NAVFAC Mid-Atlantic QAO.
Technical communications for project implementation, and data interpretation	CH2M HILL STCs/Subject-Matter Experts (SMEs)	Tom Roth	(404) 474-7640	Contact senior consultant regarding questions/issues encountered in the field, input on data interpretation, as needed. Sr. Consultant will have 24 hours to respond to technical field questions as necessary. Additionally, Sr. consultant will review of the data as necessary prior to partnering team discussion and reporting review.

QAPP Worksheet #6—Communication Pathways (continued)

Communication Drivers	Responsible Affiliation	Name	Phone Number and/or E-mail	Procedure
Communications regarding project management and implementation	CH2M HILL PM	Dan Hockett	(704) 543-3264	All information and materials about the project will be forwarded to the Navy NTR/RPM, AM, and Senior Consultant as necessary. POC for field sampling team. Responsible for field team members' and subcontractors adherence to work plan.
H&S	CH2M HILL SSC	TBD	TBD	Responsible for the adherence of team members to the site safety requirements described in the Site Specific Health and Safety Plan (SSHSP). Will report H&S incidents and near losses to PM.
Work Plan or QAPP changes in field/ Field Progress Reports	FTL	TBD	TBD	Documentation of deviations from the Work Plan will be made in the field logbook (made with the approval of AM and/or QAO) and the PM will be notified immediately. Provide daily progress reports to PM. Deviations will be made only with approval from the PM.
Field CAs	CH2M HILL FTL	TBD	TBD	The need for CA for field and analytical issues will be determined by the FTL and AQM. The AQM will ensure QAPP requirements are met by field staff. The FTL will notify the PM of any needed field CAs. The PM will have 24 hours to respond to the request for field CA.
Data tracking from collection through upload	CH2M HILL Project Geophysicist	Matt Barner	(704) 543-3273	The Project Geophysicist will track data from collection through upload for review to ensure work plan requirements are met by geophysical survey field staff. The Geophysicist will act as the main POC for the Geophysical Survey subcontractor on all data-related issues. Data collection issues will be reported to the PM within four hours.
Field and Data Collection	CH2M HILL Project Geophysicist	Matt Barner	(704) 543-3273	Any CAs for field and data collection issues will be determined by the FTL and/or the Project Geophysicist and reported to the PM within 4 hours.
Reporting Data Quality Issues	Geophysical Survey subcontractor	TBD	TBD	All QA/QC issues with project data will be reported within two days to the PM.
Technical communications for project implementation and data interpretation	AQM and MRP Technical Lead	Jessica Skeean Tim Garretson	(704) 543-3284 (904) 374-5633	Contact AQM and MRP technical lead regarding questions and issues encountered in the field and input on data interpretation, as needed. AQM and/or MRP technical lead will have 24 hours to respond to technical field questions as necessary. Responses will be communicated to the PM via e-mail or phone.

QAPP Worksheet #7—Personnel Responsibilities and Qualifications Table

Name	Title/Role	Organizational Affiliation	Responsibilities
Dave Cleland, PG	NTR	NAVFAC	Oversees project
Charity Rychak, PE	Environmental Engineer, Base EMD	MCIEAST-MCB CAMLEJ	Oversees project
Gena Townsend	USEPA RPM	USEPA	USEPA POC
Randy McElveen	NCDENR RPM	NCDENR	NCDENR POC
Matt Louth, PG	AM	CH2M HILL	Oversees project activities
Jessica Skeean, PE	AQM	CH2M HILL	Oversees project quality
Dan Hockett, PG	PM	CH2M HILL	Manages Project and coordinates project tasks and project staff
Timothy Garretson	MRP Technical Lead	CH2M HILL	Provides review and approval for all MRP-related issues for the project
Laura Cook	Navy CLEAN Program UFP-SAP Reviewer	CH2M HILL	Navy CLEAN Program UFP-SAP Reviewer
Tom Roth, PE	STC (MR)	CH2M HILL	Provides oversight and review of all MRP-related activities.
Matt Barner, PG	Project Geophysicist	CH2M HILL	Provides oversight and review of all Geophysical-Survey-related activities. Coordinates with Geophysical Survey subcontractor for data review.
Carl Woods	HSM	CH2M HILL	Prepares H&S Plan (HSP); manages H&S for all field activities
George DeMetropolis	CH2M HILL/MR Safety & Quality Control Officer	CH2M HILL	Provides MR H&S and Quality guidance for all field activities
TBD	UXO Qualified Personnel	CH2M HILL	Supervises munitions-related field activities, including MEC avoidance procedures.
TBD	FTL/SSC	CH2M HILL	Provides technical oversight and support for QAPP revisions and fieldwork implementation, supervises and coordinates field activities, and oversees H&S for field activities.
TBD	Geophysical Survey Subcontractor Team	TBD	Manages geophysical data and maintains communication with CH2M HILL PM and Project Geophysicist
Anita Dodson	Navy CLEAN Program Chemist	CH2M HILL	Provides UFP-SAP project delivery support, provides senior review of UPF-SAP prior to submittal to Navy, and performs data evaluation and QA oversight

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QAPP Worksheet #8—Special Personnel Training Requirements Table

Project Function	Specialized Training By Title or Description of Course	Training Provider	Training Date	Personnel / Groups Receiving Training	Personnel Titles / Organizational Affiliation	Location of Training Records / Certificates
Fieldwork	Munitions and explosives of concern (MEC) Awareness Training[a]	CH2M HILL UXO Qualified Personnel	Prior to mobilization	FTL (TBD), field team members (TBD), SSC (TBD), subcontractor(s)	Field team members and SSCs from CH2M HILL Field team members from subcontractor(s)	HSP file, Project folder

Notes:

[a] MEC awareness training will include Recognize, Retreat, Report (and be 3-R) training and an overview of the explosives safety submission (ESS) requirements. The 3-R training is intended to make the trainees aware of the potential presence of MEC, ways to recognize potential MEC, and what to do if potential MEC is observed. This training **DOES NOT** enable the trainee to identify the type of MEC or handle the potential MEC item. The ESS component of the training will present the requirements (e.g., procedures, separation distances, exclusion zones) to the field team.

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QAPP Worksheet #9-1—Project Scoping Session Participants Sheet

Project Name: UXO-22 MR Remedial Investigation **Projected Date(s) of Investigation**: 2013 **PM**: Dan Hockett/CH2M HILL	**Site Name**: UXO-22 **Site Location**: MCIEAST – MCB CAMLEJ, NC
Date of Session: September 12, 2012 **Scoping Session Purpose:** Discuss the path forward for UXO-22 MR investigation.	

Name	Title/Project Role	Affiliation	Phone #	E-mail Address
Dave Cleland	RPM	NAVFAC Mid-Atlantic	(757) 322-4851	dave.t.cleland@navy.mil
Charity Rychak	RPM	MCIEAST- MCB CAMLEJ EMD	(910) 451-9385	charity.rychak@usmc.mil
Gena Townsend	RPM	USEPA	(404) 562-8358	townsend.gena@epa.gov
Randy McElveen	RPM	NCDENR	(919) 707-8341	randy.mcelveen@ncdenr.gov
Matt Louth	AM	CH2M HILL	(757) 671-8311	matt.louth@ch2m.com
Kim Henderson	Deputy AM	CH2M HILL	(757) 671-6258	kim.henderson@ch2m.com
Tom Roth	STC	CH2M HILL	(404) 474-7640	Tom.roth@ch2m.com

Comments and Decisions

The Team discussed the path forward for Site UXO-22. The investigation history for UXO-22 was presented, which indicated that further investigation is required. The problem statement was defined as: Based on previous investigations and removal actions, the nature and extent of MEC and munitions constituents (MC) at Site UXO-22 is unknown.

The previous investigation results indicated that three explosives residues and several metals were detected in soil and groundwater above screening criteria. However, no unacceptable risks to human or ecological receptors were identified from exposure to explosives residues and the metals exceedances are likely associated with the long-term use as a historical storage and waste disposal area rather than with the presence of material potentially presenting an explosive hazard (MPPEH) and MEC. Therefore, no further environmental sampling is warranted under this RI. Potential MEC/ MPPEH remain on site and further investigation is required.

The RI approach was presented and agreed to by the Team to define the nature and extent of MEC/MPPEH by conducting up to 10% digital geophysical mapping (DGM) and intrusive investigation. MEC/MPPEH will be disposed of and the Team decided that post-detonation sampling is not needed due to the past site usage as a waste disposal area with land use controls (LUCs) currently in place.

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QAPP Worksheet #10—Conceptual Site Model

Objectives

Previous investigations at Site UXO-22 have identified MEC and MPPEH (CH2M HILL, 2012b) at the site. The objective of this investigation is to characterize the nature and extent of MEC/MPPEH at Site UXO-22.

This objective will be addressed by conducting an MR investigation consisting of DGM and an intrusive investigation of anomalies representing potential subsurface MEC/MPPEH (Section 3 of the **TMP**, **Appendix A**). The results of the investigation will be used in refining the conceptual site model (CSM) and to evaluate remedial alternatives in the feasibility study.

Site Location and Description

MCIEAST-MCB CAMLEJ covers approximately 236 square miles in Onslow County, North Carolina, and is bisected by the New River, which flows in a southeasterly direction toward the Atlantic Ocean (**Figure 1**). Construction of the Base began in 1941 and has since been the home of "Expeditionary Forces in Readiness" (MCIEAST-MCB CAMLEJ, 2012).

Site UXO-22 consists of portions of Installation Restoration (IR) Sites 6 and 82, which are part of OU2, located in the 'Mainside' portion of MCIEAST – MCB CAMLEJ, in Jacksonville, North Carolina. OU2 consists of IR Sites, 6, 82, and 9. Site UXO-22 encompasses approximately 75 acres of partially developed land that includes the former Defense Reutilization and Marketing Office (DRMO), Storage Lots 201 and 203 as indicated on **Figure 2**. The site is accessible by an unnamed dirt and gravel road that bisects the site from east to west connecting Holcomb Boulevard to Piney Green Road (**Figure 2**).

The topography within the central and southern portions of the site is generally level, with gentle slopes toward Wallace Creek in the northern portion of the site. The site elevation ranges between approximately 20 and 30 feet (ft) above mean sea level. A narrow ravine forms an ephemeral drainage that conveys stormwater run-off from the north-central portion of the site to Wallace Creek. Vegetative cover ranges from coniferous woodland along the eastern half and northern boundary of the site to open grassy areas within the DRMO area. The remainder of the site generally consists of compacted gravel or bare ground.

Land uses at Site UXO-22 include undeveloped vegetated areas and industrial areas, consisting of equipment staging areas (Lots 201 and 203), a groundwater treatment plant (Site 82), and parking lots.

Site History

The earliest documentation of land use at Site UXO-22 is from archival aerial photography taken in 1948 that shows cleared land, the unnamed road between Holcomb Boulevard and Piney Green Road, and areas of re-worked earth. Subsequent photographs and maps reveal the presence of structures in the 1960s that are no longer in existence. Historically, these areas of re-worked earth at Site UXO-22 were used for storage and disposal of wastes and supplies including pesticides, transformers containing polychlorinated biphenyls (PCBs), solvents, electrolytes, waste oils, batteries, and other debris such as communication wire and ordnance-related debris. Lot 201 is used to store military equipment, vehicles, hydraulic oils, and other non-hazardous supplies. Most of Lot 203 is an open field, with 21 acres formerly used from 2001 through 2012 by DRMO as a temporary scrap and surplus storage lot. No former range activities are known to have occurred at the site (CH2M HILL, 2012b).

QAPP Worksheet #10—Conceptual Site Model (continued)

Since 1983, numerous phases of environmental investigation and remediation have been conducted at OU 2. These investigations identified potential unacceptable risks from exposure to pesticides, PCBs, and metals in soil and volatile organic compounds (VOCs) and metals in groundwater at Sites 6 and 82. A Record of Decision (ROD) was signed in 1993 and identified the selected remedy to include excavation of soil to achieve industrial use, groundwater extraction and treatment to address VOCs in groundwater, long-term monitoring (LTM) to monitor groundwater and potential migration, and LUCs to prevent exposure to impacted soil and groundwater, prevent non-industrial land use, and prevent aquifer use (Baker Environmental, Inc. [Baker], 1993a). The remedies are in-place at Sites 6 and 82 and supplemental investigations and actions have been conducted and are ongoing to delineate the nature and extent of chlorobenzene contamination at Site 6, further evaluate source areas, delineate the vertical and lateral extent of VOC contamination at Site 82, and conduct additional groundwater evaluation for metals at Sites 6 and 82.

During the previous and ongoing investigation and remediation activities, MEC and MPPEH have been discovered at the site. The following MEC items have been discovered:

- 1 Mortar Shell, 81-millimeter (mm), high explosive, M43 with fuze M45 – 2010 MPPEH Pit Intrusive Investigation
- 1 Mortar Shell, 60-mm, high explosive, M49 without fuze – 2010 MPPEH Pit Intrusive Investigation
- 1 Rocket, 3.5-inch, high explosive anti-tank (HEAT), M28 – 2010 MPPEH Pit Intrusive Investigation
- 7 MK II hand grenades – 1993 Remedial Investigation (RI) and 2012 Site 6 and 82 Supplemental Investigation

Over 2,000 MPPEH items, including rocket motors, various practice projectiles, expended cartridge casings, and expended small arms ammunition casings, have been discovered at Site UXO-22. **Figure 3** presents the locations and types of MEC and MPPEH items discovered.

Following the discovery of a MPPEH burial pit between the former DRMO and Base Scales in 2008, an ESS (CH2M HILL, 2009a), and subsequent ESS Amendment (CH2M HILL, 2009b) were prepared for completing the MPPEH burial pit investigation and subsequent activities conducted at the site. Site UXO-22 was incorporated into the Munitions Response Program (MRP) in May 2010.

The table below summarizes the historical and ongoing investigations at Site UX0-22, including investigations from Site 6 and Site 82 where MEC or MPPEH were discovered.

QAPP Worksheet #10—Conceptual Site Model (continued)

Previous Investigation	Date	Activities	MEC/MPPEH Found (Quantity)
OU2 Remedial Investigation (RI) (Baker, 1993b)	1993	Evaluated the nature and extent of contamination at OU2 (Sites, 6, 9, and 82). Geophysical survey at IR Site 6 included EM-31, magnetometer and ground-penetrating radar surveys in formerly cleared areas identified on historical aerial photographs. Results indicated geophysical anomalies within the former DRMO area. A UXO survey conducted as part of the RI performed at IR Site 6 included clearance of monitoring well and soil borings and test pit and trenching activities. MEC and MPPEH items were discovered in both the subsurface and surface during clearance activities. MEC was disposed of by Base EOD and MPPEH was scrapped. Organic compounds (primarily PCBs, pesticides, VOCs, and semi-volatile organic compounds [SVOCs]) and inorganic compounds (primarily barium, cadmium, chromium, lead, manganese, and zinc) were detected in soil and groundwater at Site 6. VOCs and chlorinated VOCs were identified throughout Sites 6 and 82. The Human Health Risk Assessment (HHRA) identified potential human health risks due to exposure to vinyl chloride, arsenic, and beryllium in groundwater and PCB-1260 in biota from Wallace Creek. The findings of the Ecological Risk Assessment (ERA) indicated that OU2 may be adversely impacting the ecological integrity of Wallace Creek, Bear Head Creek, and the ephemeral drainage.	MEC • Mark II Grenade (3) MPPEH • 50-Caliber Cartridges (40) • 3.5-inch practice rockets (15) • 20-mm cartridges (10) • 30-mm cartridges (23) • 40-mm cartridges (54) • 90/95/105/106-mm cartridges (~1000) • Rocket motors, 3.5-inch (unknown) Small Arms Ammunition • 7.62-mm Ammunition rounds (100)
OU2 Time-Critical Removal Actions (TCRAs) OHM Remediation Services Corporation [OHM], 1997)	1993-1997	Aboveground storage tanks purging and removal along railroad line. Twenty drums of 4,4'-dichlorodiphenyltrichloroethane (DDT), empty drums, batteries, and debris were removed, and contaminated soil was excavated and disposed of offsite. During these actions, approximately 2,655 cubic yards of soil and debris were removed from Sites 6 and 82.	Unknown number of expended 105 mm cartridge casings discovered in battery trenches in southern portion of what is now Site UXO-22

QAPP Worksheet #10—Conceptual Site Model (continued)

Previous Investigation	Date	Activities	MEC/MPPEH Found (Quantity)
IR Site 6 Chlorobenzene Investigation (CH2M HILL, 2005, 2009c, 2010b, 2012c)	2005-2011	Surface clearance, geophysical survey, test-pitting, monitoring well installation, and groundwater and soil sampling were conducted. Surface clearance of a 1.5-acre area (MEC Surface Clearance Area on **Figure 2-3**) was conducted so that vegetation could be removed in preparation for DGM. All MPPEH recovered was reclassified as MDAS upon proper inspection and disposed of at recycling facility. During investigation activities, a MPPEH burial pit was discovered with subsequent EOD Response in December 2008. Recovered MPPEH was placed inside a secure storage container inside a 6-ft-tall chain-link fence onsite and was disposed at recycling facility in 2009. ESS and subsequent amendments were prepared, and Sited listed in the MRP in May 2010. DGM was conducted using a magnetometer along transects spaced 5 feet apart and an EM-31 conductivity instrument along transects spaced 10 feet apart over a 2.8-acre area (Geophysical Investigation Area 1 on **Figure 2-3**) to identify anomalies representing potential subsurface disposal trenches. In 2011, during test-pitting activities, three 3.5-inch rocket motors and drums containing chlorobenzene were discovered. These MPPEH items demilitarized and disposed of on July 6, 2011 by witnessed smelting. Soil samples from 12 test pits were collected for MC analysis. Eight metals (antimony, arsenic, chromium, hexavalent chromium, cobalt, iron, lead, and manganese) were detected at concentrations greater than screening criteria. The drums containing chlorobenzene were removed through a TCRA in 2011.	MPPEH • M-2 Antipersonnel, mine, bounding (4) • 57-mm brass cartridges (5) • M-29 Rocket, practice warhead only (23) • Rocket motors, 3.5-inch expended (43) • M-29 Rocket, 3.5-inch with M-405 Fuze (5) • M48 trip flares (empty), practice (8) • Full and partial 105-mm shipping containers (8) • Empty 105-mm cartridge (1) • Empty 75-mm recoilless rifle cartridge (1)

QAPP Worksheet #10—Conceptual Site Model (continued)

Previous Investigation	Date	Activities	MEC/MPPEH Found (Quantity)
IR Site 6 Intrusive Investigation (CH2MHILL, 2010a)	2010	Investigation activities at the MPPEH burial pit included removal of MPPEH and other debris to the water table or until no further visible evidence of MPPEH was observed. MEC items were disposed by controlled detonation on September 21, 2010. A total of 16,100 pounds of MPPEH was recovered during the excavation of the burial pit and disposed between February 1 and February 7, 2011 by witnessed smelting. Confirmatory soil samples were collected from the four sidewalls of the excavation. One explosives residue (2,4-dinitrotoluene) and four metals (cadmium, chromium, copper and iron) were detected in exceedance of screening criteria.	MEC • Mortar Shell, 81-mm, high explosive, M43 with fuze M45(1) • Mortar Shell, 60-mm, high explosive, M49 without fuze (1) • Rocket, 3.5-inch, HEAT, M28 (1) MPPEH • M-29 rockets, practice warhead only (39) • M-29 rocket motors, 3.5-inch, expended (52) • Stabilizer assemblies. M9 AT, rifle grenades (2) • Grenades, practice, MK21, empty (2) • Warheads for rockets, 3.5-inch, model unknown (8) • Rocket fuzes, 3.5-inch, model unknown (3) • 3.5-inch rockets believed to be M29 practice (22) • 3.5-inch rocket fuzes believed to be practice (49) • MK21 practice hand grenades (42) • M45 mortar fuze, expended (1) • Mortar shells, 60-mm, practice, M50A2 (4) • Rocket motors (1,500)
Phase II, Lot 203 Environmental Condition of Property (ECP) (Rhea Engineers and Consultants, Inc (Rhea), 2010)	2010	Records review, a geophysical survey, test-pitting, and groundwater sampling was conducted at IR Sites 6 and 82. The geophysical survey used an EM-31conductivity instrument to identify subsurface anomalies along transects spaced 40-feet apart area (Geophysical Investigation Area 2 on **Figure 2-3**). Large anomalies were detected within the former DRMO in IR Site 6 and in the southwest corner of IR Site 82. The ECP assessment concluded that the former DRMO area was suitable for its intended use with the provision that intrusive activities would not be conducted.	Unknown number of expended, unidentified small arms casings discovered in 2 of the test pits located within the former DRMO

QAPP Worksheet #10—Conceptual Site Model (continued)

Previous Investigation	Date	Activities	MEC/MPPEH Found (Quantity)
IR Site 82 Potential Source Investigation (PSI) (Rhea, 2011)	2011	Conduct an intrusive investigation to identify the nature of the geophysical anomalies discovered north of groundwater remediation system during the Phase II ECP. Vegetation clearance and excavation of test pits and trenches to a maximum depth of 18.5 ft below ground surface (bgs). Scrap metal, communications wire, batteries and MPPEH discovered and removed.	MPPEH • 75-mm cartridges (52) • 75-mm cartridge fragments (2lbs) • Propellant canister (1)
IR Sites 6 & 82 Supplemental Investigation (CH2M HILL, 2012c)	2012	During site preparation, UXO technicians identified MEC and MPPEH within the vicinity of proposed environmental sampling locations at the former DRMO. A total of 4 MEC items (MK II grenades), were found. The grenades were discovered at a depth of 4-6-inches bgs and disposed of by controlled detonation on August 16, 2012. The 40 mm cartridge casing was found on the surface and removed from the site by MCIEAST-MCB CAMLEJ EOD unit. Other MPPEH items found on the surface included 3.5" practice rocket, 3.5" rocket parts, and expended 40 mm cartridges. These items are located within the locked fenced area of the former DRMO and signs warning of potential UXO are posted.	MEC • Mark II Hand Grenade (4) MPPEH • 40-mm practice projectiles (approximately 100) • 40-mm practice cartridges (approximately 100) • M27A1 Signal Illuminating ground flares (6) • Mark 13 Grenade Diversionary (2) • 3.5" rocket motors/parts (6) • 30-mm expended cartridge casing(1) • 40 mm expended cartridge casing (1)

QAPP Worksheet #10—Conceptual Site Model (continued)

Site Geology

Site UXO-22 is underlain by light-colored, fine-grained sands extending to depths of at least 50 ft bgs, with discontinuous silty or clayey sand lenses occurring at depths from 10 to 50 ft bgs. Beneath the finer-grained lenses lie massive fine-grained sands and occasional cemented limestone beds of the River Bend and Castle Hayne formations, extending to more than 200 ft bgs. Anthropogenic disturbances have re-worked the surficial lithology up to depths of 18.5 ft bgs at select locations at the site due to excavation and dumping activities. In addition, a layer of burned material is encountered at depths of less than 5 ft bgs throughout much of the central portion of the site encompassing the DRMO.

Hydrogeology

Two aquifers are present beneath UXO-22, the Surficial and Castle Hayne aquifers. The Surficial aquifer is part of the Undifferentiated Formation which consists of unconsolidated silt, sand, and clays to approximately 25 ft bgs. The water table is encountered at approximately 5 ft bgs in the Lot 201 area of Site 6 and approximately 23 ft at Site 82 in the northern most area of UXO-22. The Surficial aquifer is typically underlain by the Belgrade Formation or Castle Hayne Confining Unit, but this unit is absent from beneath UXO-22. The River Bend formation (Castle Hayne aquifer) underlies the Undifferentiated Formation and consists of cemented sands, silt, shells, fossil fragments, and trace amounts of clay with limestone content increasing with depth (Cardinell, et al., 1993). The Castle Hayne aquifer is composed of two hydrostratigraphic units, the upper Castle Hayne and middle Castle Hayne aquifers. The Upper Castle Hayne aquifer at Site 6 extends from approximately 25 ft bgs to 90 ft bgs at and from 25 ft bgs to 60 ft bgs at Site 82. The middle Castle Hayne aquifer extends from 90 to 140 ft bgs at Site 6 and from 60 to 310 ft bgs at Site 82.

Surface Water Hydrology

Stormwater runoff from the DRMO and northern portion of Site UXO-22 is expected to flow in a northerly direction toward the ephemeral drainage and discharge into Wallace Creek located approximately 950 ft to the north (CH2M HILL, 2012d). Runoff from the area south of the unnamed road flows in a southerly direction toward Bearhead Creek (a tributary of Wallace Creek) or a stormwater retention pond directly southwest of Site UXO-22 next to the Base truck scales. Wallace Creek and Bearhead Creek ultimately drain into the New River.

Ecological Setting

Coniferous woodlands occur in the eastern portion and northern boundary of Site UXO-22. The former DRMO area is predominantly open field with the remainder of the site generally consisting of compacted gravel or bare ground. A narrow ravine extends northwest from the former DRMO and discharges into Wallace Creek. Site soils are predominantly sandy, and surface water generally infiltrates into the ground. As a result, surface water is not typically retained within the ravine, and therefore would not support aquatic receptors. Stormwater runoff discharges into the ephemeral drainage located at the northern edge of the former DRMO.

There are two types of exposure that could potentially exist at the site: (1) munitions constituents (MC) exposure from post detonation activities and (2) MEC exposure.

Conceptual Site Model

In general, the CSM relates potentially exposed receptor populations with potential source areas based upon physical site characteristics and complete exposure pathways. Important components of the CSM are the identification of potential source areas, transport pathways, exposure media, exposure pathways and routes, and receptor groups. Actual or potential exposures to human and ecological receptors associated with a site are determined by identifying the most likely, and most important, pathways of contaminant release and transport.

QAPP Worksheet #10—Conceptual Site Model (continued)

A complete exposure pathway associated with UXO-22 has three components:

- a source of MEC/MPPEH
- a pathway of exposure to the MEC/MPPEH
- actual contact with MEC/MPPEH by a receptor

Munitions constituent (MC) exposure is not considered in this QAPP because MC was addressed in the PA/SI (CH2M HILL, 2012d) and no further MC investigation is warranted based on the results of the PA/SI. Other contaminants of concern have potential unacceptable ecological risks associated with exposure to subsurface soil and the soils in the ephemeral drainage at Site UXO-22 but they will be addressed as part of the ongoing IR Sites 6 and 82 supplemental investigations.

Potential Source Areas

Based on the results of previous investigations, MEC and MPPEH have been identified at the ground surface and within the subsurface at UXO-22 as the result of former waste disposal activities.

Exposure Pathways

An exposure pathway describes the mechanisms whereby receptors come into contact with MEC/MPPEH. Exposure, and thus potential risk, can only occur if complete exposure pathways exist.

Exposure to MEC/MPPEH

A potential exposure pathway exists for human receptors to come into contact with MEC/MPPEH. A complete exposure pathway requires both access and interaction. The receptor must not only have access to an area that contains MEC/MPPEH, but the receptor's activities must be such that there is interaction with the item. Access to many areas of the site is restricted by either fencing or vegetation and terrain. Generally, the accessible open gravel areas are unlikely to contain MEC/MPPEH on the surface. Because of the existing LUCs, the posted warning signs, and the UXO awareness training, it is unlikely that site workers would come into contact with MEC/MPPEH located below surface. Unauthorized site visitors or site workers who venture outside their typical work areas could encounter MEC/MPPEH, especially in the wooded areas where MEC surface clearance has not been performed. If MEC and MPPEH of the types previously discovered are on-site and did not function as designed, the probability of an unintentional detonation by casual contact, such as accidently stepping on it, is high. More aggressive contact, such as striking the MEC and MPPEH or putting it in a fire, would make the probability of detonation even higher.

QAPP Worksheet #11—Project Quality Objectives and Systematic Planning Process Statements

Problem Definition

Based on previous investigations and removal actions, the nature and extent of MEC at Site UXO-22 has not been completely characterized.

The following munitions questions will be answered by the MR investigation:

1. **What is the extent and density of MEC at Site UXO-22?**

   A DGM survey will be performed on approximately 7.5 acres or 10 percent of the site to identify geophysical anomalies that represent potential subsurface MEC. A MEC/MMPEH intrusive investigation will be performed on a portion of the geophysical anomalies identified during the DGM. A random sampling approach, as described in Section 3 of the TMP (Appendix A), will be used to draw a statistically representative selection of geophysical anomalies representing potential subsurface MEC/MMPEH from both high and low anomaly density areas. The intrusive investigation of discrete anomalies will be performed to a maximum depth of 2 feet bgs. Areas of saturated geophysical response will be investigated to a maximum depth of 4 feet bgs unless the water table is first encountered. The DGM survey may also identify potential waste disposal pits. If suspected waste disposal pits are identified, debris in the pit will be investigated to the degree necessary to evaluate the general contents rather than to remediate the disposal pit.

   A surface sweep to identify MPPEH in the former DRMO lot is planned as a potential pre-RI activity to enhance safety and to limit the interference to DGM caused by metallic surface debris; however, the surface sweep has not yet been funded. The findings of the surface sweep will be included in the RI.

2. **What types of MEC/MPPEH are present?**

   MEC/MPPEH types will be indentified during the intrusive investigation.

Who will use the data?

- DGM data will be used to identify and to locate anomalies for intrusive investigation.
- The data will be used by the Navy, USEPA, and NCDENR to determine whether further investigation may be required to evaluate the hazards associated with the site and to provide information for evaluating remedial alternatives for a FS.

What are the Project Action Limits (PALs)?

- If anomalies are identified that represent potential subsurface MEC during the DGM activities, a portion of the anomalies will be intrusively investigated.
- A portion of DGM anomalies will be intrusively investigated to evaluate the nature of buried metallic objects.
- The proposed DGM survey may identify potential waste disposal pits. During the intrusive investigation, a portion of potential disposal pits will be investigated to characterize their contents (rather than remove all contents).

For what will the data be used?

Data collected during this MR investigation will be used to evaluate the nature and extent of MEC/MPPEH to assist with future decision-making processes with regards to Site UXO-22. Specific data uses are outlined below.

DGM data collected will be used to:

- Identify geophysical anomalies that represent potential subsurface MEC
- Assist in planning the MEC intrusive investigation

QAPP Worksheet #11—Project Quality Objectives and Systematic Planning Process Statements (continued)

Data collected during the intrusive investigation will be used to:

- Characterize the nature and extent of MEC and MPPEH
- Evaluate remedial action alternatives in the FS

What types of data are needed?

DGM data is required to identify geophysical anomalies representing potential subsurface MEC. Based on the DGM data, an intrusive investigation will be performed on a statistical number of anomalies to assess the source of the DGM anomalies. The combined results of the DGM and intrusive investigation will meet the objective of characterizing the nature and extent of MEC. Refer to **Worksheet #10** (Problem Definition) and the **Geophysical Investigation Plan (GIP)** in **Appendix B** for further information.

How "good" does the data need to be in order to support the environmental decision?

- The positional data must be of sufficient accuracy to allow reacquisition of anomalies representing potential MEC/MPPEH for subsequent investigations. Measurement performance criteria are provided in **Worksheet #12-1** and are described in the **GIP (Appendix B)** and the **Geophysical System Verification (GSV) Plan (Appendix C)**.
- The specific QC audit procedures for the definable features of work (DFOWs) to be employed at Site UXO-22, including the phase during which it is performed, the frequency of performance, the pass/fail criteria, and actions to take if failure occurs, are presented in the **GIP (Appendix B)**.

How much data should be collected?

DGM will be performed across 10 percent of the 75-acre site as indicated on **Figure 4**.

An intrusive investigation will be performed on a statistically representative portion of the geophysical anomalies representing potential subsurface MEC as described in **Section 4** of the **TMP (Appendix A)**.

Where, when, and how should the data be collected and generated?

- DGM will be performed across accessible areas of the site using a Geonics EM61-MK2. The EM61-MK2 data will be used to identify geophysical anomalies representing potential subsurface MEC.
- The schedule of activities is presented in **Worksheet #16**.
- Data will be collected and generated in accordance with the procedures outlined in this QAPP. Specifically, see the **TMP** (**Appendix A**) for more details.

Who will collect and generate the data? How will the data be reported?

- DGM data will be collected and reported by a qualified geophysical operator (TBD). Geophysical data will be provided via a Secure File Transfer Protocol (FTP) site maintained by CH2M HILL. Data will also be provided on DVD or CD with the final report as detailed in the **GIP** (**Appendix B**).
- The MPPEH/MEC intrusive investigation will be conducted by qualified UXO subcontractors supervised by CH2M HILL UXO personnel in accordance with **Section 4** of the **TMP** (**Appendix A**).

How will the data be archived?

No analytical laboratory data will be collected. The DGM and intrusive investigation results will be included in the RI report and archived as part of the Administrative Record.

QAPP Worksheet #11—Project Quality Objectives and Systematic Planning Process Statements (continued)

PQOs listed in the form of if / then qualitative and quantitative statements.

The level of data to be collected during this investigation does not allow for a quantitative risk-based decision. Therefore, specific "quantitative" PQOs have not been developed. Data from this investigation may be used during future project activities to further develop PQOs for additional investigations or activities. General "qualitative" PQOs are provided as follows, in the form of if/then statements, to summarize the objectives of this investigation.

- If no geophysical anomalies are identified as representing potential subsurface MEC, then the site will be evaluated to assess the need for additional investigation.
- If geophysical data collected indicate the presence of geophysical anomalies representing potential subsurface MEC, then an intrusive investigation will be conducted to evaluate the nature and extent of MEC/ MPPEH in preparation for a Feasibility Study.
- If intrusive activity extends to a maximum depth of two feet bgs and anomaly sources representing potential MEC still remain, those locations will either be reinvestigated or a comment will be entered along with the investigation results indicating the suspected reason.
- If the intrusive investigation identifies MEC, the item will be destroyed through onsite controlled detonation in accordance with the ESS. The location of the MEC item will be recorded using a handheld global positioning system (GPS) so the coordinate data can be entered into the NIRIS database for reporting purposes.
- If the intrusive investigation identifies MPPEH, the item will be placed in a temporary accumulation point and managed in accordance with the ESS. MPPEH will be visually inspected and independently reinspected for explosive hazards. MPPEH that cannot be classified as MDAS will be disposed of in the same manner as MEC. MDAS will be transported offsite. The location of MPPEH will be recorded using a handheld GPS so the coordinate data can be entered into the NIRIS database for reporting purposes.

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QAPP Worksheet #12-1—Measurement Performance Criteria Table (MR)

DFOW with Auditable Function	Responsible Person(s)[1]	Audit Procedure[2]	QC Phase[3]	Freq. of Audit	Pass/Fail Criteria	Action if Failure Occurs
Planning						
Geographic Information System (GIS) Setup (Pre-mobilization Activities)	Project GIS Manager	Verify GIS system has been set up and is ready for site data.	PP	O	GIS system has been set up and is ready for site data.	Do not proceed with field activities until criterion is passed.
Document management and control (Pre-mobilization Activities)	PM	Verify appropriate measures are in place to manage and control project documents.	PP	O	Appropriate measures are in place to manage and control project documents.	Do not proceed with field activities until criterion is passed.
Data Management (Pre-mobilization Activities)	PM, Data Manager	Verify appropriate measures are in place to manage and control project data.	PP	O	Appropriate measures are in place to manage and control project data.	Do not proceed with field activities until criterion is passed.
Subcontracting (Pre-mobilization Activities)	PM, Site Manager	Verify subcontractor qualifications, training, and licenses.	PP/IP	O	Subcontractors' qualifications, training, and licenses are up to date and acceptable.	Ensure subcontractor provides the qualifications, training, and licenses or change subcontractor.
Technical and Operational approach (Technical Project Planning)	PM	Verify technical and operational approaches have been agreed on by the project team.	PP/IP	O	Technical and operational approaches have been agreed on by project team and incorporated into the Work Plans.	Do not proceed with field activities until criterion is passed
GSV Plan preparation and approval	PM	Verify GSV Plan has been prepared and approved.	PP/IP	O	GSV Plan has been approved.	Do not proceed with field activities until criterion is passed.
GSV Report	PM, Project Geophysicist	Verify recommendations in GSV Report for DGM system and associated DQOs have been approved	PP/IP	O	Recommendations for DGM equipment and associated DQOs are approved by the United States Army Corps of Engineers	Do not proceed with DGM field activities until recommendations of GSV Report are approved.
Work Plan preparation and approval	PM	Verify Work Plan prepared and approved.	PP/IP	O	Work Plan has been approved	Do not proceed with field activities (excluding site mobilization) until criterion is passed.
Field Operations						
Site preparation (Mobilization)	Site Manager	Verify local agencies are coordinated.	PP/IP	O	Local agencies are coordinated.	Do not proceed with field activities until criterion is passed.
Site preparation (Mobilization)	Site Manager	Verify equipment has been inspected and tested.	PP/IP	E	Equipment passes inspection and testing.	Proceed only with activities for which equipment has passed inspection and testing.
Site preparation (Mobilization)	Site Manager	Verify communications and other logistical support are coordinated.	PP/IP	O	Communications and other logistical support are coordinated.	Do not proceed with field activities until criterion is passed.
Site preparation (Mobilization)	Site Manager	Verify emergency services have been coordinated.	PP/IP	O	Emergency services are coordinated.	Do not proceed with field activities until criterion is passed.
Site preparation (Mobilization)	Site Manager	Verify site-specific training is performed and acknowledged.	PP/IP	O	Site-specific training is performed and acknowledged	Do not proceed with field activities until criterion is passed.
Site preparation (Mobilization)	Site Manager	Hold pre-mobilization meeting and Operations Readiness Review (ORR) with the project team.	PP/IP	O	Project plans are reviewed and acknowledged by team members.	Do not proceed with field activities until criterion is passed.
Site Preparation (Site Survey)	PM	Verify surveyor qualifications.	PP/IP	O	Surveyor's qualifications are up to date and acceptable.	Ensure surveyor provides the qualifications prior to starting work or change surveyor.
Site Preparation (Site Survey)	PM	Verify surveyor's licenses are up to date and acceptable.	PP/IP	O	Surveyor's licenses are up to date and acceptable.	Ensure surveyor provides the licenses prior to starting work or change surveyor.
Site Preparation (Site Survey)	Site Manager	Verify benchmarks for survey have been established and documented.	PP/IP	O	Benchmarks for survey have been established and documented.	Ensure benchmarks for survey are established and documented prior to performing survey.
Site Preparation (Site Survey)	Site Manager	Verify site boundaries and grids have been established.	PP/IP	O	Site boundaries and grids have been established.	Do not proceed with dependent field activities until criterion is passed.
Site Preparation (Site Survey)	Site Manager	Verify surveyor notes are legible, accurate, and complete.	IP	O	Surveyor notes are legible, accurate and complete.	Ensure surveyor replaces deficient notes with legible, accurate and complete notes.

QAPP Worksheet #12-1—Measurement Performance Criteria Table (MR) (continued)

DFOW with Auditable Function	Responsible Person(s)[1]	Audit Procedure[2]	QC Phase[3]	Freq. of Audit	Pass/Fail Criteria	Action if Failure Occurs
Site Preparation – (Vegetation Removal)	Site Manager	Verify personnel qualifications and training.	PP/IP	O	Personnel qualifications and training are appropriate.	Ensure subcontractor provides appropriately trained and qualified personnel or replace with properly trained personnel.
Site Preparation (Vegetation Removal)	Site Manager	Verify environmental controls are correct and functional.	IP/FP	O	Environmental controls are correct and functional.	Ensure that appropriate environmental controls are in place prior to proceeding with vegetation removal.
Site Preparation (Vegetation Removal)	Site Manager	Verify vegetation removal is conducted according to Work Plan.	FP	D	Verify vegetation removal is conducted according to the Field Investigation Plan (Chapter 3 of Work Plan).	Stop vegetation removal activities until full compliance can be assured and any activities not performed within compliance are re-evaluated and re-performed if necessary.
GSV Execution	PM, Project Geophysicist	Verify DQOs established in GSV Plan have been accomplished.	PP/IP	O	DQOs identified in GSV Plan have been achieved.	Continue with GSV until DQOs are achieved.
DGM Survey	Project Geophysicist	Verify DGM Survey conducted in accordance with GIP (**Appendix B**) and DGM SOPs: EM61-MK2 Metal Detection Munition Response Surveys Geophysical Surveying with EM61-MK2 Configuration and Operation of the GPS Base-Station System Configuration and Operation of the GPS Rover System Field Methodology and Survey Setup	IP/FP	O/D	DGM Survey conducted in accordance with GIP (**Appendix B**) and DGM SOPs.	Stop activity until full compliance can be assured and any activities not performed within compliance are re-evaluated and re-performed if necessary.
DGM Survey	Project Geophysicist	Check results of QC tests performed as specified in the QCP and DGM SOPS.	FP	E	QC tests must pass in accordance with standards determined during the GSV and referenced SOPs.	If a QC test does not pass, a root-cause analysis must be performed and the project team must meet to discuss and determine appropriate action.
DGM Survey	Project Geophysicist	Confirm that DGM survey DQOs established during GSV are being met.	FP	E	DGM survey DQOs are being met.	If the DQOs are not being met, a root-cause analysis must be performed and the project team must meet to discuss and determine appropriate action.
DGM Data processing	Project Geophysicist	Verify data checks specified in QCP and SOPs: EM61-MK2 Data Processing and Database management Uploading and Downloading Data to the File Transfer Protocol (FTP) Site	FP	E	Data checks must pass in accordance with standards determined during the GSV and referenced SOPs.	If a QC test does not pass, a root-cause analysis must be performed and the project team must meet to discuss and determine appropriate action.
Reacquisition Accuracy	Project Geophysicist	Confirm that anomalies are located within a 1-meter radius of flagged location as selected by DGM.	FP	E	Anomaly located within 1-meter radius of flag	If anomalies are being located beyond 1-meter radius of flag or are not being located within 1-meter radius of the flag, a root-cause analysis must be performed and the project team must meet to discuss and determine appropriate action.
Intrusive Investigation	UXO Quality Control Specialist (UXOQCS)	Verify equipment tested IAW the Work Plan	IP/FP	D	Equipment testing performed and tests passed	Repair or replace instrument.
Intrusive Investigation	UXOQCS	Verify team separation distance is as established per the ESS	IP/FP	D	Team separation distance is appropriate for work being performed	Stop activities until appropriate separation distance is being followed
Intrusive Investigation	UXOQCS	Verify that the anomaly recovered during intrusive excavations is appropriate to the amplitude of the initial anomaly detected during the DGM.	IP/FP	D	Recovered anomaly is appropriate to the amplitude of the initial anomaly detected during the DGM.	Return to the location of the anomaly excavation to determine if additional anomalies are present. If anomalies being recovered continue to be inappropriate for the amplitude as detected during the DGM, a root-cause analysis must be performed and the project team must meet to discuss and determine appropriate action.
Intrusive Investigation	QC Geophysicist	QC seed items to be placed at detectable depths IAW GSV and/or Work Plan	IP/FP	E	All QC seed items in area of operation recovered.	A root-cause analysis must be performed and the project team must meet to discuss and determine appropriate action
Intrusive Investigation	UXOQCS	Verify operations are conducted IAW ESS, TMP, GIP, MEC Removal SOPs, and the HSP: - Survey/Sweeps - MEC Surface Sweeps - Analog Detection and Removal Actions - DGM Anomaly Investigation - Ammunition and Explosives Transportation - Explosives Storage and Accountability - Disposal/Demolition Operations - Scrap Inspection Operations	IP/FP	D	Work performed IAW Work Plan, referenced MEC SOPs, and the HSP.	Stop activity until full compliance can be assured and any activities not performed within compliance are re-evaluated and re-performed if necessary
MPPEH Management	UXOQCS	Verify inspections conducted IAW ESS	IP/FP	D/E	Inspections being conducted IAW the QAPP	Stop activity until full compliance can be assured and any activities not performed within compliance are re-evaluated and re-performed if necessary

QAPP Worksheet #12-1—Measurement Performance Criteria Table (MR) (continued)

DFOW with Auditable Function	Responsible Person(s)[1]	Audit Procedure[2]	QC Phase[3]	Freq. of Audit	Pass/Fail Criteria	Action if Failure Occurs
MPPEH Management	UXOQCS	Verify certification conducted IAW ESS	IP/FP	D/E	Certification is conducted IAW the TMP	Stop activity until full compliance can be assured and any activities not performed within compliance are re-evaluated and re-performed if necessary
MPPEH Management	UXOQCS	Verify disposal is conducted IAW ESS	IP/FP	D/E	Disposal is conducted IAW the TMP	Stop activity until full compliance can be assured and any activities not performed within compliance are re-evaluated and re-performed if necessary
Site Restoration	Site Manager	Verify the damage caused by excavation and removal of anomalies is backfilled and laid to original grade and completed IAW the TMP.	FP	O	Damage caused by excavation and removal of anomalies is backfilled and laid to original grade	Ensure that damage caused by excavation and removal of anomalies is backfilled and laid to original grade
Demobilization	PM	Verify facilities-support infrastructures are dismantled and shipped to appropriate location and area is returned to original condition.	FP	O	Facilities-support infrastructures are dismantled and shipped to appropriate location and site is returned to original condition.	Ensure that all support facilities are removed and that the site is returned to original condition.
Final Project Reports and Closeout						
RI Report preparation and approval	PM	Verify all phases of environmental investigation were performed correctly and are complete.	FP	O	Investigation performed is accurate and complete.	investigation performed is accurate and complete
Archiving	GIS Manager	Verify data back-up systems are in place.	IP	O	Data back-up systems are in place	Ensure data back-up systems are in place
Project Closeout	PM	Verify purchase orders have been closed out.	IP	O	Purchase orders have been closed out	Ensure purchase orders are closed out
Project Closeout	PM	Verify invoices completed and approved.	IP	O	Invoices completed and approved	Ensure invoices are completed and approved

Notes:
IAW = in accordance with

QC Phase	Frequency
PP = Preparatory Phase	O = Once
IP = Initial Phase	D = Daily
FP = Follow-up Phase	W = Weekly
	E = Each occurrence

[1] The responsible person (if other than the MEC QCS) is the individual with whom the MEC QCS will coordinate with to ensure compliance with requirements and to verify that any necessary follow-up actions are taken.
[2] Where appropriate, a reference has been included referring the reader to a more detailed description of the procedures being audited.
[3] Documentation to be in accordance with the three-phase control process as outlined in the Quality Control Plan.

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QAPP Worksheet #13—Secondary Data Criteria and Limitations Table

Secondary Data	Data Source	Data Generator (s)	How Data Will Be Used	Limitations on Data Use
Locations and types of MEC found	Baker. 1993b. Remedial Investigation Report for Operable Unit No. 2, MCIEAST – MCB CAMLEJ, North Carolina	Baker, environmental sampling to assess the nature and extent of impacts in all site media resulting from historical site use.	Report lists uncovered MPPEH and/or MEC items	MEC list may not be inclusive of all potential MEC at Site UXO-22
	OHM. 1997. Closeout Report Sites 6 &82 Source Removal, Operable Unit No. 2, MCIEAST – MCB CAMLEJ, North Carolina	Baker and OHM, conducted source removal from areas within IR Site 6 and IR Site 82.		
	CH2M HILL. 2010. Final Site 6 Chlorobenzene Investigation Summary Report, MCIEAST – MCB CAMLEJ, North Carolina	CH2M HILL, conducted plume delineation and geophysical survey to detect source.		
	Rhea 2010. *Final Phase II Lot 203 Environmental Condition of Property DRMO Area,* MCIEAST – MCB CAMLEJ, North Carolina	Rhea, evaluated whether environmental problems exist (prior to beginning lease renewal negotiations).		
	Earth Resources Technology, Inc. *2010. Draft After Action Report—Results of Excavation Activities at Operation Unit (OU) 2, Site 82,* MCIEAST – MCB CAMLEJ, North Carolina	Rhea and Earth Resources Technology, Conducted an intrusive investigation to identify the nature of the geophysical anomalies discovered north of water treatment plant during Phase II ECP.		
	CH2M HILL. 2011. Final, Time-Critical Removal Action Summary, Site 6-Storage Lots 201 and 203, Technical Memorandum, MCIEAST – MCB CAMLEJ, North Carolina	CH2M HILL, expanded and removed all MPPEH from burial pit discovered during the chlorobenzene investigation.		
	CH2M HILL. 2012. Preliminary Assessment (PA)/Site Inspection (SI) Report for Site UXO-22, MCIEAST – MCB CAMLEJ, North Carolina.	CH2M HILL, assessed the presence of MC and metals downgradient of MEC/MPPEH point sources.		

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QAPP Worksheet #14—Summary of Project Tasks

Activities to be performed at this site have been divided into DFOWs as well as the tasks to be completed for each of these definable features. Procedures for these tasks, including QC checks, recording and correcting data, data processing, data management, and information management, will be performed in accordance with the **TMP (Appendix A)** listed in **Worksheet #23** of this QAPP.

DFOW	Tasks
Pre-mobilization Activities	GIS Setup Document Management and Control Data Management Subcontractor Procurement
Mobilization and Site Preparation	Mobilize Crew and Equipment Onsite Document Review Communications and Logistics Establishment Local Agencies and Emergency Services Notification Site Specific Training DGM transect Establishment Clear Vegetation QC Seed Emplacement
Geophysical Investigation	Equipment Testing Review of Work Methods Geophysical Survey (EM61-MK2) Data Transfer/Upload to FTP
Data Evaluation	QC Review of Field Data Pre-processing of Data Geophysical Data Processing and Interpretation QC of Final Data Selection of anomalies for intrusive investigation
Surface Sweep – Former DRMO lot	Equipment assisted surface sweep to evaluate MPPEH on surface Destroy MEC items by detonation Confirm that all MPPEH has been documented as MDAS with all required documentation. MDAS will be transported offsite for thermal destruction.
MEC Intrusive Investigation	Re-acquire anomalies identified for investigation during DGM Excavate Anomaly Sources Destroy MEC items by detonation Removal Verification Verification of QC Seed Recovery Confirm that 100 percent of selected geophysical anomalies have been re-acquired and investigated Confirm that all MPPEH has been documented as MDAS with all required documentation. MDAS will be transported offsite for thermal destruction.
Demobilization	Demobilize Crew and Equipment
Final Report and Closeout	Data Compiling and Reporting Report Preparation Data Archiving Procurement Closeout

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QAPP Worksheet #15—Reference Limits and Evaluation Table

Matrix:

Analytical Group:

Concentration Level:

Analyte	Chemical Abstract Service (CAS) Number	Tap Water Regional Screening Levels (RSLs) (micrograms per liter [µg/L])	Maximum Contaminant Levels (MCLs) (µg/L)	Practical Quantitation Limit (PQL) Goal (µg/L)	Laboratory-Specific Limits	
					Quantitation Levels (QLs) (µg/L)	Method Detection Limits (MDLs) (µg/L)

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QAPP Worksheet #16—Project Schedule / Timeline Table

Activities	Organization	Dates		Deliverable	Deliverable Due Date
		Anticipated Date of Initiation	Anticipated Date of Completion		
MR QAPP					
Pre-Draft QAPP	CH2M HILL	06/25/2012	03/15/2012	Pre-Draft UFP QAPP	03/18/2013
Navy/Navy Chemist/Base MR Review	NAVFAC	03/18/2013	04/12/2013	Comments on Pre-Draft UFP QAPP	
Draft QAPP	CH2M HILL	04/15/2013	04/26/2013	Draft UFP QAPP	04/29/2013
Partnering Team Review	NAVFAC, MCIEAST-MCB CAMLEJ,NCDENR, USEPA, CH2M HILL	04/29/2013	05/24/13	Comments on Draft UFP QAPP	
Final QAPP	CH2M HILL	5/27/2013	06/07/2013	Final UFP QAPP	06/10/2013
Field Investigation					
Subcontractor Procurement	CH2M HILL	02/08/2013	08/02/2013		
Field Investigation	CH2M HILL, subcontractors (TBD)	09/2013	12/2013		
Remedial Investigation Report					
Pre Draft RI	CH2M HILL	01/06/2014	02/28/2014	Pre Draft RI	03/03/2014
Navy/Base MR Review	NAVFAC	03/03/2014	03/21/2014	Comments on Pre-Draft RI	
Draft RI	CH2M HILL	03/24/2014	04/04/2014	Draft UFP SAP	04/07/2014
Partnering Team Review	NAVFAC, MCIEAST-MCB CAMLEJ, EPA, NCDENR	04/07/2014	05/21/2014	Comments on Draft RI	
Final RI	CH2M HILL	05/29/2014	06/04/2014	Final RI	06/07/2014

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QAPP Worksheet #17—Sampling Design and Rationale

The objective of this RI is to evaluate the nature and extent of MEC/MPPEH at Site UXO-22. This section of the QAPP details the specific DFOWs to be performed to meet the objectives of the investigation. The DFOWs and tasks to be performed during this investigation are presented in **Worksheet #14** and detailed as follows. The schedule of activities for the project is indicated in **Worksheet #16**. Each of these work elements for the investigation and other supporting documentation for performing the investigation are presented in the following table.

DFOW Table	Supporting Document(s)
Pre-Mobilization Activities	QAPP, Scope of Work
Mobilization and Site Preparation	QAPP
Geophysical Survey	QAPP, GIP, Scope of Work
Geophysical Data Processing/ Interpretation	QAPP, GIP, Scope of Work
Intrusive Investigation	QAPP, Scope of Work, ESS
Demobilization	QAPP
Final Report and Closeout	QAPP, Scope of Work

Pre-Mobilization Activities

This QAPP has been developed to provide detail for how the project will be performed and the quality standards to which it will be compared. Prior to mobilization to the site, this plan will be reviewed and approved by CH2M HILL, the Navy, Base, and the regulators. Additionally, coordination will be made to ensure GIS information and equipment are available and updated for project activities, document and data management procedures are in place, and all subcontractors have been procured. Subcontractor qualifications, certifications, and licenses will be reviewed prior to selection.

Mobilization and Site Preparation

All required field personnel, equipment, and materials will be mobilized to Site UXO-22. Onsite personnel will review this QAPP and all applicable SOPs and appendices. Appropriate site-specific training, including H&S review for site activities, geophysical survey training, and MEC Awareness Training will be verified or performed. Minimum training requirements are listed in **Worksheet #8**. Additionally, a daily morning safety meeting will be conducted to review the tasks to be performed that day and any potential hazards present.

All equipment will be inspected upon arrival at the site, will be tested for functionality, and will be repaired or replaced as necessary to ensure quality performance. Equipment inspections will also be performed daily throughout the project to ensure proper functionality and prevent any damage. Good housekeeping procedures will be followed to reduce the risk of equipment damage. Other equipment and requirements will be outlined in the SSHSP.

The FTL will ensure that onsite communications (such as mobile phones, two-way radios) have been established among team members. The FTL will also ensure that the MCIEAST-MCB CAMLEJ Environmental Manager and NCDENR have been notified of site activities and have in place proper emergency response actions.

Prior to the geophysical survey, vegetation clearing will be performed to facilitate site access. The geophysical survey area will be 1 meter wide transects spaced 8.4 meters apart throughout the Munitions Response Site (MRS). These transects will be established to survey-grade accuracy by a professional land surveyor prior to the start of DGM.

QAPP Worksheet #17—Sampling Design and Rationale (continued)

UXO qualified personnel will implement MEC avoidance measures to prevent unintentional contact with potential MEC during land surveying and vegetation clearing activities.

Geophysical Survey

After site-setup activities have been completed, DGM will be performed at the site. Note that required QC checks of the equipment, as described in **Worksheet #12-1b** and **Appendix B**, will be performed throughout the survey process.

See the **GIP**, included as **Appendix B,** for geophysical survey details.

Geophysical Data Processing and Interpretation

See the **GIP**, included as **Appendix B,** for geophysical survey details. Once QC review of the geophysical data has been performed, the data will be evaluated for selection of targets that may represent potential MEC/MPPEH as detailed in **Section 3** of the **TMP**, **Appendix A**.

Intrusive Investigation

If geophysical data indicate the presence of geophysical anomalies representing potential subsurface MEC, an intrusive investigation will be performed on a select number of those anomalies. Anomalies will be selected for the intrusive investigation using the Estimating a Portion method, described in **Section 3** of the **TMP** (**Appendix A**), which draws a statistically representative selection of anomalies from both higher density and lower density areas.

The proposed DGM survey may also identify potential waste disposal areas or waste disposal pits that may also contain MEC/MPPEH. If waste disposal areas are identified, the disposal area will be investigated with the intent of characterizing the contents, rather than remediating the disposal pit by complete excavation.

The UXO Team performing MEC/MPPEH intrusive investigation will be composed of qualified UXO technicians supervised by a UXO Technician III. MR work will take place under the guidance of a Senior UXO Supervisor (SUXOS). Safety will be overseen by a UXO Safety Officer (UXOSO), and QC requirements will be implemented by a UXOQCS. The MEC/MPPEH intrusive investigation will be performed as detailed in **Section 3** of the **TMP** (**Appendix A**).

Final Report and Closeout

At the conclusion of all field activities and data processing and interpretation, a draft RI report will be prepared to document the findings of the field investigation. The report will be submitted electronically for concurrent review by NAVFAC and MCIEAST-MCB CAMLEJ. Following receipt of review comments, CH2M HILL will issue a revised draft report to NAVFAC, MCIEAST-MCB CAMLEJ, USEPA and NCDENR for review. A final report will be prepared that will address all comments received on the draft document. The report will summarize the site history, all field activities, geophysical data, and the findings of the MEC intrusive.

QAPP Worksheet #18—Sampling Locations and Methods and Standard Operating Procedure Requirements Table

Data collection activities performed at the site will include a geophysical investigation as indicated on **Figures 4**.

Location	Exclusion Areas	Matrix	Depth relative to Ground Surface	Survey Methodology	Degree of Investigation or Coverage	SOP Reference
Site UXO-22	None	Soil	**Unknown**	Geonics EM61-MK2	10% of the MRS	SOP #1

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QAPP Worksheet #19—Analytical SOP Requirements Table

Matrix	Analytical Group	Analytical and Preparation Method/ SOP Reference[1]	Containers	Sample Volume	Preservation Requirements (Chemical, Temperature, Light Protected)	Maximum Holding Time (Preparation/Analysis)[2]

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QAPP Worksheet #20—Field Quality Control Sample Summary Table

Matrix	Analytical Group	No. of Sampling Locations	No. of Field Duplicates	No. of Matrix Spike/Matrix Spike Duplicates (MS/MSD)	No. of Field Blanks	No. of Equip. Blanks	Total No. of Samples to Lab

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QAPP Worksheet #21—Project Sampling SOP References Table

Reference Number	Title, Revision Date, and/or Number	Originating Organization of Sampling SOP	Equipment Type	Modified for Project Work? (Y/N)	Comments
TBD	DGM Surveying	Geophysical Survey Subcontractor	Geonics EM61-MK2	TBD	TBD

* SOP will be provided by the subcontractor upon award.

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QAPP Worksheet #22—Field Equipment Calibration, Maintenance, Testing, and Inspection Table

See also **Worksheet #12-1b**.

Field Equipment	Activity[a]	Frequency	Acceptance Criteria	CA	Responsible Person	SOP Reference	Comments
DGM Equipment Warm-up	Verification	At the beginning of each work day	System has warmed up for a minimum of 10 minutes (longer in cold weather)	Repair/replace equipment components until functioning properly.	Equipment operator	GIP (**Appendix B**)	QC Geophysicist to evaluate whether warm-up period was sufficient through data collection notes
DGM System Personnel Test	Testing	At the beginning of each work day	Data spikes no greater than 2 millivolts (mV), or 2 nanoteslas (nT) from the mean, for the EM61-MK2.	Operator checks self for sources of metallic interference (such as cell phone, steel-toe boots); repair/replace equipment components until functioning properly.	Equipment operator	GIP (**Appendix B**)	QC Geophysicist to evaluate test compliance during daily data review
DGM System Cable Shake Test	Testing	At the beginning of each work day	Data spikes no greater than 2 mV, or 2 nT from the mean, for the EM61-MK2	Repair/replace equipment components until functioning properly.	Equipment operator	GIP (**Appendix B**)	QC Geophysicist to evaluate test compliance during daily data review

[a] Activities may include: calibration, verification, testing, and/or maintenance.

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QAPP Worksheet #23—Analytical SOP References Table

Lab SOP Number	Title, Revision Date, and/or Number	Definitive or Screening Data	Matrix and Analytical Group	Instrument	Organization Performing Analysis	Modified for Project Work (Y/N)

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QAPP Worksheet #24—Analytical Instrument Calibration Table

Instrument	Calibration Procedure	Frequency of Calibration	Acceptance Criteria	CA	Person Responsible for CA	SOP Reference

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QAPP Worksheet #25—Analytical Instrument and Equipment Maintenance, Testing, and Inspection Table

Instrument/ Equipment	Maintenance Activity	Testing Activity	Inspection Activity	Frequency	Acceptance Criteria	CA	Responsible Person	SOP Reference

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QAPP Worksheet #26—Sample Handling System

SAMPLE COLLECTION, PACKAGING, AND SHIPMENT
SAMPLE ARCHIVING
SAMPLE DISPOSAL

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QAPP Worksheet #27—Sample Custody Requirements Table

Field Sample Custody Procedures (sample collection, packaging, shipment, and delivery to laboratory):
Laboratory Sample Custody Procedures (receipt of samples, archiving, and disposal):
Sample ID Procedures:
Chain-of-custody Procedures:

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QAPP Worksheet #28—Laboratory QC Samples Table

Matrix	
Analytical Group	
Analytical Method/ SOP Reference	

QC Sample:	Frequency/Number	Method/SOP QC Acceptance Limits	CA	Person(s) Responsible for CA	Data Quality Indicator (DQI)	Measurement Performance Criteria
Method Blank						
Laboratory Control Sample (LCS)						
Internal Standards						
System Monitoring Compounds/ Surrogates						

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QAPP Worksheet #29—Project Documents and Records Table

Document/Report/Form	Generator	DFOW	Frequency of Completion	Location/Where Maintained
Field Notebook	CH2M HILL FTL	All Fieldwork	Daily	Hard copy onsite then in project file, copies saved on CH2M HILL's local server
Fieldwork Plans	CH2M HILL	Pre-mobilization activities	Once prior to beginning fieldwork	Hard copy onsite then in project file, copies saved on CH2M HILL's local server
CA Forms	CH2M HILL	All Fieldwork	As necessary	CH2M HILL's local server and project file
Electronic Data Deliverables	CH2M HILL and Geophysical Survey Subcontractor	Geophysical Survey/Data Transfer	As necessary based upon data collection	CH2M HILL's local server
Meteorological Data from Field	CH2M HILL	All Fieldwork	Daily	Field Notebook
Equipment/Instrument check logs	CH2M HILL and Geophysical Survey Subcontractor	Geophysical Survey	As required by this QAPP	Hard copy onsite then in project file, copies saved on CH2M HILL's local server
Geophysical Survey subcontractor notes and field logs	Geophysical Survey Subcontractor	Geophysical Survey	Daily	Onsite then transfer copy to CH2M HILL to store on local server
Pre-Processed Data	CH2M HILL and Geophysical Survey Subcontractor	Geophysical Survey and Data Evaluation	As necessary	Subcontractor data base and CH2M HILL local server
Final Geophysical Survey Data	CH2M HILL and Geophysical Survey Subcontractor	Geophysical Survey and Data Evaluation	As necessary	Subcontractor data base and CH2M HILL local server
Field Photo Log	CH2M HILL	All Fieldwork	Daily/As necessary	CH2M HILL local server
Daily Project Reports	CH2M HILL	All Fieldwork	Daily	CH2M HILL's local server, hard copy onsite then in project file
Daily H&S Documents	CH2M HILL	All Fieldwork	Daily	CH2M HILL's local server, hard copy onsite then in project file
Training Records	CH2M HILL and Geophysical Survey Subcontractor	All Fieldwork	Prior to mobilization to the site	Hard copy onsite and with Human Resources

QAPP Worksheet #29—Project Documents and Records Table (continued)

Document/Report/Form	Generator	DFOW	Frequency of Completion	Location/Where Maintained
Meeting Agendas, Minutes, Presentation, and so forth	CH2M HILL	All DFOWs	As necessary	CH2M HILL local server
Summary Reports	CH2M HILL	Final Reports and Closeout	Once upon completion of site activities	CH2M HILL local server
Anomaly Tracking (paper forms or electronic data management system using hand held devices)	CH2M HILL	Intrusive Investigation	For each anomaly representing potential MEC investigated	Hard copy/electronic management system onsite, then in project file, copies saved on CH2M HILL's local server
DD Form 1348-1	CH2M HILL	Demilitarization of MDAS	For each MDAS item demilitarized	Hard copy onsite then in project file, copies saved on CH2M HILL's local server

QAPP Worksheet #30—Analytical Services Table

Matrix	Analytical Group	Sample Locations/ID Number	Analytical Method	Data Package Turnaround Time	Laboratory/Organization	Backup Laboratory/Organization

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QAPP Worksheet #31—Planned Project Assessments Table

Assessment Type	Frequency	Internal or External	Organization Performing Assessment	Person(s) Responsible for Performing Assessment	Person(s) Responsible for Responding to Assessment Findings	Person(s) Responsible for Identifying and Implementing CA	Person(s) Responsible for Monitoring Effectiveness of CA
Field Performance Audit	Once during field event	Internal	CH2M HILL	FTL and or Geophysicist	FTL, Geophysical Subcontractor	FTL, Geophysical Subcontractor	CH2M HILL
Data storage and transfer system check	Prior to initial data collection and once weekly	Internal	CH2M HILL	CH2M HILL Geophysicist	Geophysical Subcontractor	Geophysical Subcontractor	CH2M HILL

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QAPP Worksheet #32—Assessment Findings and Corrective Action Responses

Assessment Type	Nature of Deficiencies Documentation	Individual(s) Notified of Findings	Timeframe of Notification	Nature of CA Response Documentation	Individual(s) Receiving CA Response	Timeframe for Response
Field Performance Audit	Checklist and Written Audit Report	Dan Hockett/CLT PM, CH2M HILL	Within 1 week of audit	Memorandum	CH2M HILL FTL CH2M HILL Geophysicist	Within 1 week of receipt of CA Form

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QAPP Worksheet #32-1—Corrective Action Form

Person initiating CA _____ Date _____

Description of problem and when identified (Submit a drawing or sketch if necessary): _____

Cause of problem, if known or suspected: _____

Resolution/Sequence of CA: (including date implemented, action planned, and personnel/data affected)

CA implemented by: _____ Date: _____

CA initially approved by: _____ Date: _____

Follow-up date: _____

Final CA approved by: _____ Date: _____

Information copies to:

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QAPP Worksheet #32-2—Field Performance Audit Checklist

Project Responsibilities

Project No.: _____ Date: _____

Project Location: _____ Signature: _____

Team Members:

Yes _ No _ 1) Is the approved work plan being followed?

Comments _____

_____

Yes _ No _ 2) Was a briefing held for project participants?

Comments _____

_____

Yes _ No _ 3) Were additional instructions given to project participants?

Comments _____

_____

DGM Operations

Yes _ No _ 1) Are routine inspections and QC checks of the equipment being performed as outlined in this QAPP?

Comments _____

_____

Yes _ No _ 2) Is the proposed location of grid lines clearly communicated with the DGM Survey Team?

Comments _____

_____

Yes _ No _ 3) Are data collection being performed as required by the QAPP?

Comments _____

_____

Yes _ No _ 4) Are data stored properly and uploaded for transfer in a timely manner?

Comments _____

_____

QAPP Worksheet #32-2—Field Performance Audit Checklist (continued)

Yes _ No _ 5) Are photographs taken and documented?

Comments _____

_____

Document/Data Control

Yes _ No _ 1) Are all work plan documents available onsite for review?

Comments _____

_____

Yes _ No _ 2) Are daily reports and other documentation completed as required by the QAPP?

Comments _____

_____

Yes _ No _ 3) Are equipment QC data and collected field data properly transferred? Review?

Comments _____

_____

QAPP Worksheet #33—QA Management Reports Table

Type of Report	Frequency	Projected Delivery Date	Person Responsible for Report Preparation	Report Recipient(s)
Daily QC Report	Daily	Following Day	Site QC Manager	Dan Hockett/ CH2M HILL
QC Meeting Minutes	Post Meeting	Within 7 days	Site QC Manager	Dan Hockett/ CH2M HILL
Preparatory Inspection Forms	Once for each applicable DFOW (prior to start of task)	With daily reports the following day after meeting	Site QC Manager	Dan Hockett/ CH2M HILL
Initial Inspection Forms	Once for each applicable DFOW (prior to start of task)	With daily reports the following day after meeting	Site QC Manager	Dan Hockett/ CH2M HILL
Follow-Up Inspection Forms	Once for each applicable DFOW (document in daily reports)	Document in Daily Reporting	Site QC Manager	Dan Hockett/ CH2M HILL
Draft RI Report	Post Field Event	October 25, 2013	Dan Hockett/CH2M HILL	Stakeholders, see **Worksheet #4**

The RI report will address the following:

- Summary of project QA/QC requirements and procedures
- Conformance of project to the QAPP requirements and procedures
- Deviations from the QAPP and any approved amendments
- Summary of the identity and extent of MEC/MPPEH
- Documentation of disposition of all recovered MEC/MPPEH
- Documentation of disposal of all resulting MDAS
- Conclusions and recommendations for path forward

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QAPP Worksheet #34—Verification (Step I) Process Table

Verification Input	Description	Internal / External	Responsible for Verification
Evidence of required approval of plan (QAPP)	Evidence of approval and completeness of QAPP. Includes establishment of PQOs, QC criteria, SOPs, PALs, figures, and so forth.	Internal	PM, CH2M HILL
Site-Specific Training Records	Ensure project personnel have proper training and certification to perform site activities and achieve project data quality objectives.	Internal	PM, CH2M HILL
Geophysical Survey Data Methods	Geophysical survey data methods will be reviewed to ensure data collection is performed as defined in the QAPP.	Internal	FTL and Geophysicist CH2M HILL
Data Collection and Transfer	Ensure data collection is complete and recorded accurately and that data transfer protocol is adequate.	Internal	PM, CH2M HILL
Performance requirements (including QC criteria)	Ensure performance requirements are fully established (see **Worksheet #12-1b** and **Worksheet #15**).	Internal	PM, CH2M HILL
Field Log Notebooks	Field notes will be reviewed to ensure completeness of field data collection, data collection times, site operations, site conditions, and so forth. The logbook will also be used to document, explain, and justify all deviations from the approved QAPP and other work planning documents.	Internal	PM, CH2M HILL

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QAPP Worksheet #35—Validation (Steps IIa and IIb) Process Table

Step IIa[a] / IIb[b]	Validation Input	Description	Responsible for Validation (name, organization)
IIb	Onsite Screening	Ensure that all field data meet work plan requirements for completeness and accuracy based on the field calibration records.	FTL, CH2M HILL
IIa	Geophysical Survey Data Methods	Verify that all data collected were in accordance with the SOPs and requirements of the QAPP. Ensure that any deviations from the QAPP are documented.	FTL and Geophysicist, CH2M HILL
IIa	Data Collection and Transfer	Ensure that all data are usable and have been corrected in accordance with data processing procedures defined in the SOPs.	Geophysicist, CH2M HILL
IIa	Performance Requirements (including QC criteria)	Establish that QC tests were performed and compliant with method-required limits as specified in **Worksheet #12-1b**.	FTL and Geophysicist, CH2M HILL
IIa	Field Log Notebooks	Review field logbooks, field documents, and data deliverables for compliance to methods and signatures.	FTL and PM, CH2M HILL
IIb	Performance Requirements (including QC criteria)	Ensure that the data report has been provided and that all data are complete. Evaluate whether all data collection procedures were followed with respect to the equipment and QC process.	Geophysicist, CH2M HILL

[a] IIa = compliance with methods, procedures, and contracts. [b] IIb = comparison with measurement performance criteria in the QAPP.

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QAPP Worksheet #36—Analytical Data Validation (Steps IIa and IIb) Summary Table

Step IIa / Ib	Matrix	Analytical Group	Validation Criteria	Data Validator (title and organizational affiliation)

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QAPP Worksheet #37—Usability Assessment

Summarize the usability assessment process and all procedures, including interim steps and any statistics, equations, and computer algorithms, that will be used:

- If all QC criteria are met, then the data are usable.
- If QC criteria are not met, then data are suspect and cannot be used until confirmed. Recollection of data may be required.

Describe the evaluative procedures used to assess overall measurement error associated with the project.

- To assess whether a sufficient quantity of acceptable data are available for decision-making, the data will be reviewed by MEC-experienced data processing geophysicists.
- If significant inconsistencies in data are detected, they will be evaluated to assess impact on decision making.
- If significant deviations are noted between QC of equipment, background information, and field data, the cause will be further evaluated to assess impact on decision making.

Describe the documentation that will be generated during the usability assessment and how usability assessment results will be presented so that they identify trends, relationships (correlations), and anomalies:

- Data tables will be produced for geophysical data and will reflect which anomalies were selected as significant and which were eliminated from consideration during data interpretation.
- Graphical representations and site representative figures will be produced to reflect the areas that are most likely to contain MEC.
- The final report will identify any data usability limitations and recommend additional investigations if necessary.
- A data quality evaluation section will be included as part of the final report to summarize the results of the data collection and interpretation.
- The final report will identify any data usability limitations and recommend CA if necessary.

Identify the personnel responsible for performing the usability assessment.

- The PM, Project Geophysicist, and other team members will be responsible for collecting and compiling the data. The data will then be presented to the Navy, MCIEAST- MCB CAMLEJ, NCDENR and USEPA, which will evaluate the data usability according to project objectives.

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Figures

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Legend

- Highways
- UXO-22 Boundary
- Installation Boundary

N

0 7,500 15,000 30,000 Feet

1 inch = 15,000 feet

Figure 1
Base Location Map
Site UXO-22 UFP-SAP
MCIEAST-MCB CAMLEJ
North Carolina

CH2MHILL

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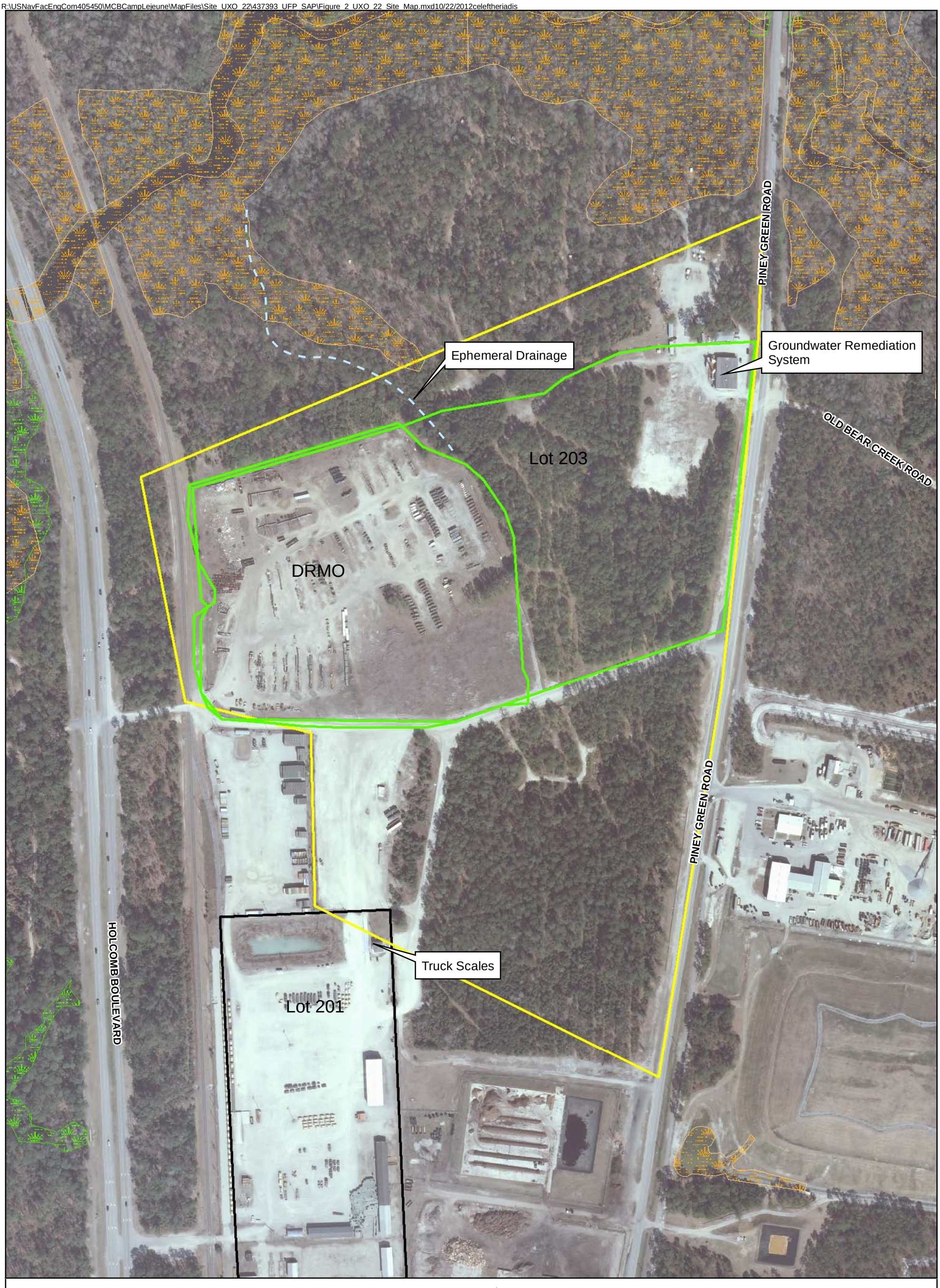

Legend

- Ephemeral Drainage Feature
- UXO-22 Boundary
- Planning Wetland Area
- Jurisdictional Wetland Area
- DRMO-Defense Reutilization and Marketing Office
- Lots 201 and 203

N

0 150 300 600 Feet

1 inch = 300 feet

2009 Aerial Photograph

Figure 2
Site Map
Site UXO-22 UFP-SAP
MCIEAST-MCB CAMLEJ
North Carolina

CH2MHILL

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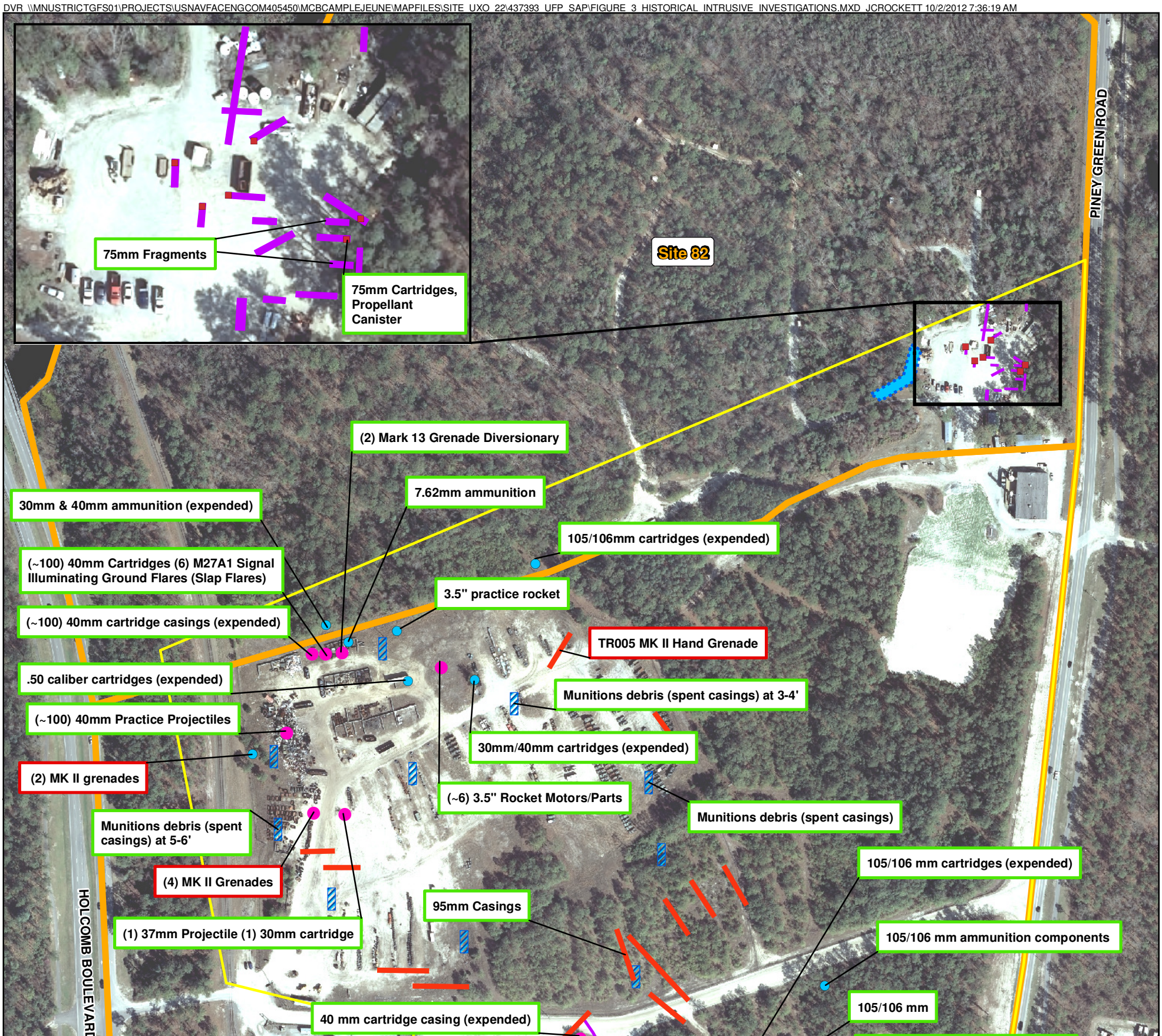


Legend

- Test Pit (Rhea, 2011)
- Site 6 Chlorobenzene Investigation Test Pits (CH2M Hill, 2010)
- RI Soil Boring Location (Baker, 1993)
- Field Reconnaissance (CH2M Hill, 2012)
- Trench (Baker, 1993)
- MPPEH Disposal Pit (CH2M Hill, 2009)
- OU2 Boundary
- Trench (Rhea, 2011)
- Phase II ECP DRMO Test Pit (Rhea, 2010)
- Source Removal Trenches (OHM, 1997)
- MEC Surface Clearance Area (CH2M Hill, 2009)
- UXO-22 Boundary

MEC Item

MPPEH Item

N

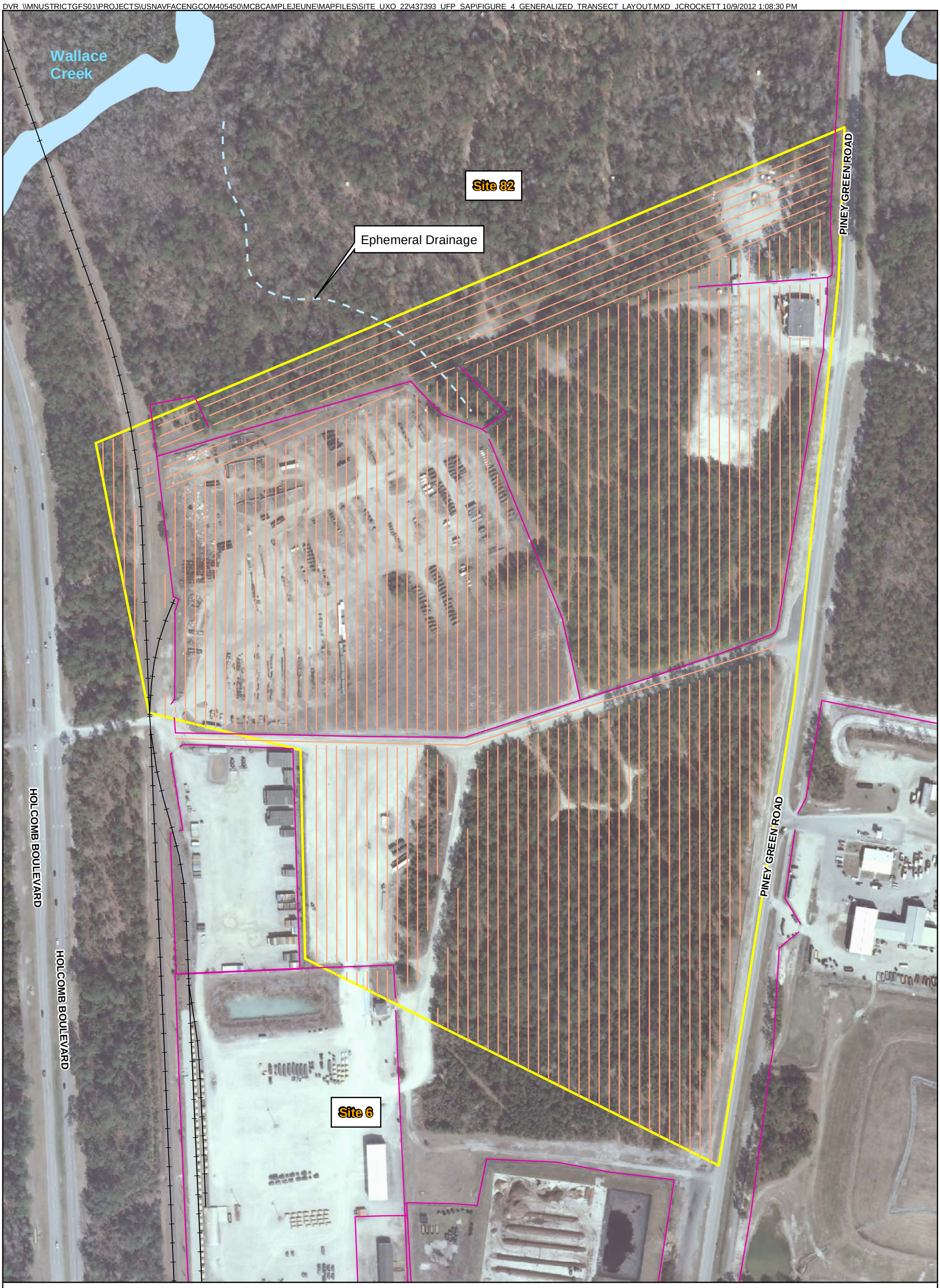
0 125 250 500 Feet

1 inch = 250 feet

Figure 3
Historical Munitions Related Intrusive Investigation Results
Site UXO-22 UFP-SAP
MCIEAST-MCB CAMLEJ
North Carolina

CH2MHILL

DVR \\MNUSTRICTGFS01\PROJECTS\USNAVFACENGCOM405450\MCBCAMPLEJEUNE\MAPFILES\SITE_UXO_22\437393_UFP_SAP\FIGURE_4_GENERALIZED_TRANSECT_LAYOUT.MXD JCROCKETT 10/9/2012 1:08:30 PM



Legend

- Ephemeral Drainage Feature
- Fence Line
- Transects
- Railroad
- Surface Water
- UXO-22 Boundary

N

0 125 250 500 Feet

1 inch = 250 feet

Figure 4
Generalized Transect Layout
Site UXO-22 UFP-SAP
MCIEAST-MCB CAMLEJ
North Carolina

CH2MHILL

Appendix A
Technical Management Plan

Appendix A

Technical Management Plan
for Munitions Response Investigation
at
Site UXO-22, Former Munitions Disposal Area

Marine Corps Installations East- Marine Corps Base Camp Lejeune
North Carolina

Contract Task Order WE54

August 2013

Prepared for

Department of the Navy
Naval Facilities Engineering Command

Under the

NAVFAC CLEAN 8012 Program
Contract N62470-11-D-8012

Prepared by

Charlotte, North Carolina

Contents

Attachment

Tables

Figures

Acronyms and Abbreviations

AHA	Activity Hazard Analysis
BIP	blow-in-place
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act of 1980
CWM	chemical warfare materiel
DDESB	Department of Defense Explosives Safety Board
DGM	digital geophysical mapping
DoD	Department of Defense
ESS	Explosives Safety Submission
EZ	exclusion zone
FS	Feasibility Study
GSV	Geophysical System Verification
HASP	Health and Safety Plan
HE	high explosive
INRMP	Integrated Natural Resource Management Plan
LUC	land use control
MCIEAST–MCB CAMLEJ	Marine Corps Installations East–Marine Corps Base Camp Lejeune
MDAS	material documented as safe
MEC	munitions and explosives of concern
MGFD	munitions with the greatest fragmentation distance
mm	millimeter
MPP	Master Project Plans
MPPEH	material potentially presenting an explosive hazard
MR	munitions response
MRP	Munitions Response Program
MRS	Munitions Response Site
PA/SI	Preliminary Assessment/Site Inspection
PM	Project Manager
QA	quality assurance
QAPP	Quality Assurance Project Plan
QC	quality control
RCW	red-cockaded woodpecker
RI	Remedial Investigation
SM	Site Manager
SOP	Standard Operating Procedure
SUXOS	Senior Unexploded Ordnance Supervisor
TMP	Technical Management Plan
UFP	Uniform Federal Policy
USFWS	United States Fish and Wildlife Service
UXO	unexploded ordnance
UXOSO	Unexploded Ordnance Safety Officer
UXOQCS	Unexploded Ordnance Quality Control Specialist

SECTION 1

Introduction

Under the Military Munitions Response Program and pursuant to the Comprehensive Environmental Response, Compensation, and Liability Act of 1980 (CERCLA), Marine Corps Installations East–Marine Corps Base Camp Lejeune (MCIEAST–MCB CAMLEJ) is in the process of addressing munitions and explosives of concern (MEC) and material potentially presenting an explosive hazard (MPPEH) at Site Unexploded Ordnance (UXO) 22 – Former Munitions Disposal Area. CH2M HILL, on behalf of MCIEAST–MCB CAMLEJ, has conducted a Preliminary Assessment/Site Inspection (PA/SI) for Site UXO-22. Based on the results of the PA/SI, the site is proceeding to the next phase of the CERCLA process, Remedial Investigation (RI)/Feasibility Study (FS).

1.1 Background and Project Objectives

The purpose of the RI is to define the nature and extent of MEC/MPPEH contamination by associated with Site UXO-22, the former Munitions Disposal Area. Digital geophysical mapping (DGM), analog electromagnetic detector survey, and intrusive investigation of anomalies selected as potentially representing subsurface MEC will be performed over 10 percent of the Munitions Response Site (MRS). Data from these activities will be combined with previous investigation data to characterize the nature and extent of MEC/MPPEH at Site UXO-22 in support of the identification and screening of remedial alternatives in the FS.

1.2 Scope of Work

The following activities will be performed at Site UXO-22 in accordance with the methods and procedures detailed in the MCIEAST–MCB CAMLEJ Munitions Response Program (MRP) Master Project Plans (MPP) (CH2M HILL, 2008):

- Vegetation clearance and DGM in 10 percent of the investigation area
- Manual excavation and identification of anomaly sources selected from the DGM as representing potential subsurface MEC
- Demolition of all MEC encountered
- Inspection of demilitarization of all MPPEH encountered
- Anomaly removal verification and excavation backfilling
- Transportation of material documented as safe (MDAS) offsite for processing
- Preparation of an After Action Report when it is determined that all munitions response (MR) actions are complete
- Preparation of an RI report summarizing the results of the intrusive investigation

1.3 Guidance, Regulations, and Policies

The Site UXO-22 RI will be conducted under the guidance documents, regulations, and polices described in Section 2.1 of the MRP MPP (CH2M HILL, 2008).

1.4 Explosives Safety Submission

The intrusive investigation will be conducted in accordance with the Department of Defense Explosives Safety Board (DDESB)-approved (June 6, 2009) Explosives Safety Submission (ESS) (ESS-104) (CH2M HILL, 2009a), ESS Amendment No. 1 (ESS-107) (CH2M HILL 2009b), and DDESB-approved (May 2, 2011) ESS Amendment No. 3 (ESS-120) (CH2M HILL, 2010). The ESS and associated amendments will conform to all applicable Marine Corps, Department of the Navy, and Department of Defense (DoD) requirements for the safe handling of MEC and explosives.

1.5 MEC Contingency Procedures

Based on the documented history of DoD activities at Site UXO-22, it is anticipated that if MEC is discovered it can be destroyed onsite through intentional detonation. Therefore, alternatives to onsite disposal are not identified in this Technical Management Plan (TMP). Likewise, the discovery of MEC that cannot be identified is not anticipated. If MEC items are discovered that cannot be identified, MEC contingency procedures will be followed in accordance with Section 2.2 of the MRP MPP.

1.6 Chemical Warfare Materiel Contingency Procedures

Based on the documented history of DoD activities at Site UXO-22, it is not anticipated that chemical warfare materiel (CWM) will be discovered. However, if it is encountered, all work will immediately cease and CWM contingency procedures will be conducted in accordance with Section 2.3 of the MRP MPP (CH2M HILL, 2008).

SECTION 2

Field Investigation Plan

The following subsections describe the procedures associated with site preparation, site restoration, and DGM investigation. Section 3 describes procedures for the intrusive investigation and MEC/MPPEH management.

2.1 Site Preparation and Restoration

The following activities will be conducted to prepare and restore the investigation area.

2.1.1 Buried Utility Clearance

The North Carolina One-Call Center will be contacted regarding planned intrusive investigation. An insured subsurface utility locator will be subcontracted by CH2M HILL to locate and mark underground utilities at the site. Buried utilities will be identified within a 20-foot radius of transects.

2.1.2 Site Survey

Land surveying services will be conducted in accordance with Section 7.4 of the MRP MPP (CH2M HILL, 2008) and are expected to be completed under two mobilizations:

- **Phase 1** will be a survey of the MRS boundary (**Figure 2** of the Uniform Federal Policy [UFP]-Quality Assurance Project Plan [QAPP]). This survey will delineate the extent of the MRS and the areas that will be subjected to vegetation clearing for the DGM effort.
- **Phase 2** will occur after vegetation clearing and will consist of the layout of transects (**Figure 4** of the UFP-QAPP). Approximately 99,573 linear feet (10 percent of the MRS) of transects (1-meter wide) will be marked in the MRS.

The intrusive investigation subcontractor will ensure that all surveying required for reacquisition of selected anomalies is performed.

During all phases of surveying activities, MEC avoidance will be conducted in accordance with the site-specific Health and Safety Plan (HASP), standard operating procedures (SOPs), and Activity Hazard Analyses (AHAs) (**Appendix A** of the UFP-QAPP). UXO technicians will escort surveying personnel while onsite and will practice anomaly avoidance at all locations where stakes are driven.

2.1.3 Vegetation Clearing

Vegetation clearance will be conducted to facilitate access for DGM and intrusive investigation activities. Vegetation less than 3 inches in diameter will be removed to within 6 inches of the ground surface using a combination of mechanical and manual methods, depending on site conditions. Mechanical removal may include use of chain saws, brush cutters, and grinders, while manual removal may include use of loppers, hand saws, or similar hand tools. Felled brush and trees will be left on the site. Trees greater than 3 inches in diameter, if there are any, will not be removed without prior Base approval. Overhanging vines and protruding branches that could interfere with the safe and effective performance of investigation activities will also be removed.

During the vegetation removal process, UXO technicians will conduct MEC avoidance activities in accordance with the HASP, SOPs, and AHAs (**Appendix A** of the UFP-QAPP).

2.1.4 Site Restoration and Demobilization

Site Restoration

Damage caused by equipment or other site activities (such as deep ruts, intrusive investigation, or sampling holes) will be repaired, and the site will be re-vegetated as necessary to prevent erosion.

Demobilization

Full demobilization will occur when the project is completed and appropriate quality assurance (QA)/quality control (QC) checks have been performed. The following activities will occur prior to demobilization:

- Anomaly source removal verification will be completed
- Verification of adequate site restoration at the site will be completed
- All field equipment will be inspected, packaged, and shipped to the appropriate location

2.2 DGM Investigation

The following subsections summarize the procedures for the DGM investigation and its associated reporting requirements.

2.2.1 Geophysical Investigation Plan

DGM will be conducted over 10 percent of the MRS using an EM61-MK2 to map geophysical anomalies that could potentially represent subsurface MEC. The EM61-MK2 is a high-resolution time-domain electromagnetic instrument designed to detect, with high spatial resolution, shallow ferrous and non-ferrous metallic objects. In areas where DGM cannot be conducted due to site conditions, such as wetlands that preclude vegetation clearance, handheld metals detectors such as the Schonstedt GA-52Cx or equivalent will be used to locate anomalies. DGM transects are indicated on **Figure 4** of the UFP-QAPP. The DGM area is estimated as 7.5 acres. Transects that cannot be completed using DGM equipment will be completed using the “mag and dig” method.

A total of nine QC seed items will be emplaced within the DGM and “mag and dig” transects (one per 13,124 feet of transects) to validate the DGM surveys and the intrusive operations at the site. Industry standard objects (NRL, 2009) will be used as blind QC seeds in the areas to be surveyed to perform ongoing verification that the DGM system is properly functioning and that the munitions detection and positioning data quality objectives are continuing to be met. QC seeds will be placed with the intent of a DGM or “mag and dig” team encountering at least one per day. Due to production variability, weather conditions and other logistical considerations, there may be days in which a seed is not within the survey area.

Each blind seed will be placed at an easily detectable depth (in order that a response can be evaluated against the expected response for that item, in the case of DGM transects), and the depth, orientation, and azimuth will be recorded. The depth will be measured to the center mass of the item. The location of each item will then be surveyed by a land surveyor.

The location of blind seeds will not be shared with personnel performing DGM surveys and data processing/ interpretation or intrusive operations until those tasks have been completed.

The Geophysical Investigation Plan provided in **Appendix C** of the UFP-QAPP provides additional details of the equipment, approach, methods, operational procedures, and QC to be used in performing the geophysical investigations.

2.2.2 Statistics-Based Investigation Methodology

After DGM activities are complete and all DGM data have been submitted to CH2M HILL from the DGM subcontractor, the CH2M HILL project geophysicist will select the geophysical anomalies to be intrusively investigated utilizing the Estimating a Proportion statistical technique. This technique is defensible and based on statistical significance, described as follows.

Using the following statistical sample size formulas for categorical data, it is possible to determine the necessary sample size of geophysical anomalies to be intrusively investigated and classified within a population of anomalies (that is, within a transect or site). One can extrapolate the sample population investigation results to estimate the proportion of MEC to non-MEC across the population within an acceptable confidence limit and margin of error. When a population size is large or unknown:

$$n_0 = \frac{Z_\alpha^2 pq}{e^2}$$

When a population size is finite or known (finite population correction):

$$n_1 = \frac{n_0}{1 + \left(\frac{n_0}{N}\right)}$$

Z_α = desired confidence level
p = proportion of MEC classified geophysical anomalies
q = proportion of non-MEC classified geophysical anomalies (q = 1-p)
e = acceptable margin of error for proportion being estimated
n_0 = statistical sample size for a large population
n_1 = adjusted statistical sample size for a finite population
N = size of the population (number of geophysical anomalies along a transect segment)

When estimating the variance of proportional variables (that is, MEC or non-MEC), it is most conservative to estimate a population proportion of 50 percent (p=0.5); the result is that variance (pq) is maximized and thus, the required sample size is also maximized.

Using a z-statistic for a 90 percent confidence level (Z_α=1.645) and a margin of error of 5 percent (e=0.05), the solution for n_0:

$$n_0 = \frac{Z_\alpha^2 pq}{e^2} = \frac{1.65_\alpha^2 (0.5)(0.5)}{0.05^2} = 272$$

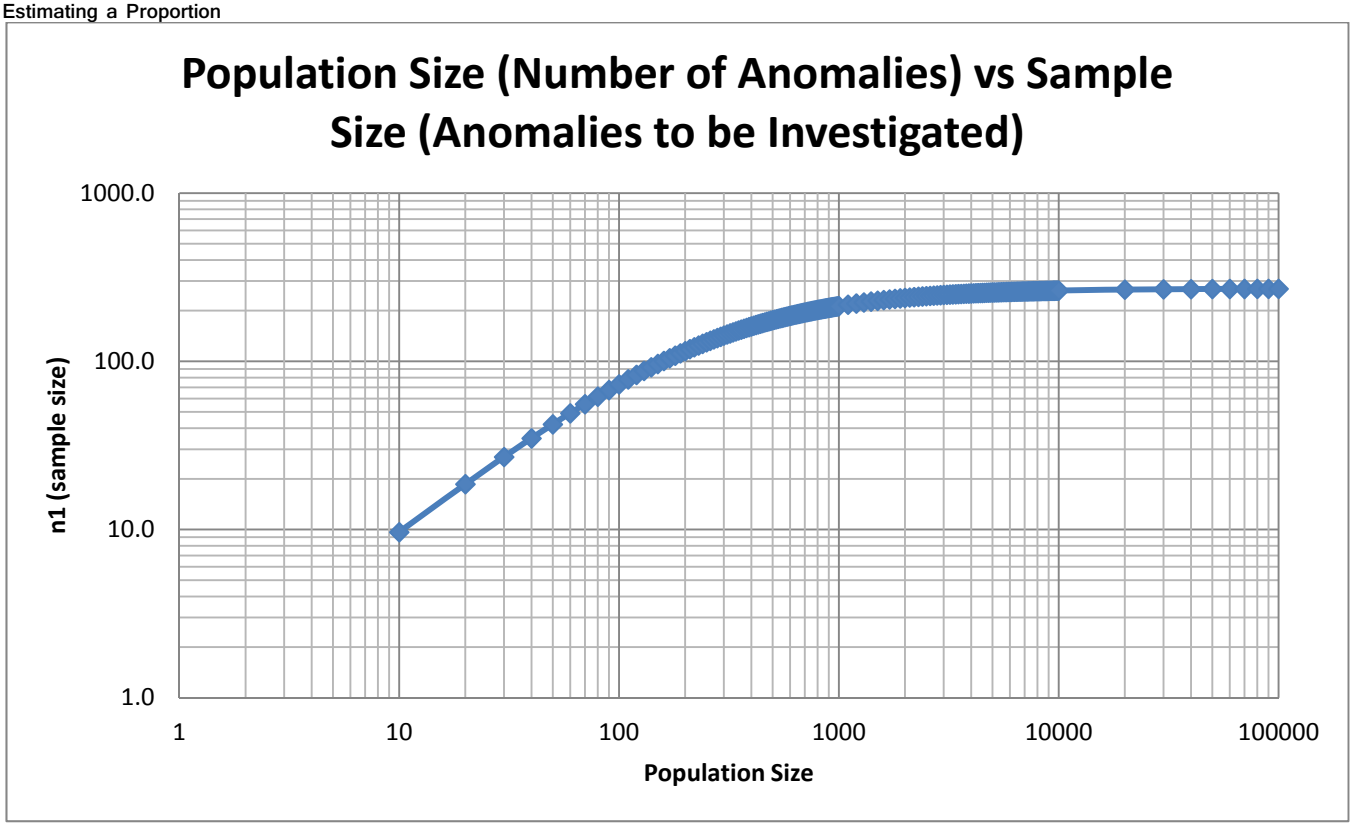
This formula calculates that a maximum of 272 geophysical anomalies need to be classified to determine with 90 percent confidence and +/- 5 percent sampling error the proportion of MEC to non-MEC geophysical anomalies in a large or unknown population.

Once the number of geophysical anomaly contacts has been determined in a population, one can use the total number of contacts as the total population (N). If n_0 is greater than 5 percent of N ($N*0.05 > n_0$), one can further reduce the required sample size. Thus, within a population, once N is known, one can reduce the required sample size by solving for n_1:

$$n_1 = \frac{n_0}{1 + \left(\frac{n_0}{N}\right)} = \frac{272}{1 + \frac{272}{N}}$$

This formula allows scaling of sample size to the appropriate quantity based on the number of contacts discovered within a population and the pre-determined confidence level and acceptable margin of error. The calculated results for various population sizes are presented on **Figure 2-1**.

FIGURE 2-1
Estimating a Proportion



2.2.3 Geophysical System Verification Plan

A Geophysical System Verification (GSV) will be performed as part of the process for validating DGM systems to be utilized during the DGM activities. The GSV Plan is provided in **Appendix D** of the UFP-QAPP**,** which provides details of the equipment, approach, methods, operational procedures, and QC to be used in performing GSV at Site UXO-22.

2.2.4 Geospatial Information and Electronic Submittals

Methods, equipment, accuracy, and submittal requirements for location surveys and mapping are described in Section 7.4 of the MRP MPP (CH2M HILL, 2008).

SECTION 3

MEC Intrusive Investigation Plan

A MEC intrusive investigation will be conducted to evaluate the nature and extent of MEC/MPPEH that may be present at the site. A statistically representative portion of the anomalies selected as representing potential subsurface MEC/MPPEH will be reacquired and intrusively investigated. The equipment, approach, methods, operational procedures, and QC to be used during the intrusive investigations are detailed as follows.

3.1 MEC Removal Operations

For DGM transects, a statistically representative portion of anomalies selected as potentially representing subsurface MEC will be reacquired and intrusively investigated. Excavation of overburden covering individual anomaly sources will be performed using hand-excavation tools, such as shovels, spades, trowels, and pry bars, or earth-moving equipment. Confirmed MEC will be disposed of by controlled detonation using blow-in-place (BIP) methods or relocated for controlled detonation and/or consolidated shots if the item is safe to move. Following demolition or removal of the MEC item, the area will be rechecked with an appropriate geophysical instrument to ensure that another item was not hidden beneath the item removed. The excavation team will then record the results of the excavation and record the geophysical instrument response during checking of the hole.

3.1.1 DGM Transects

Anomaly Reacquisition

All geophysical anomalies identified for excavation will be reacquired by an intrusive investigation team, composed of UXO technicians, to an exact location using a real-time kinematic global positioning system. If the anomaly is not immediately intrusively investigated, the location will be flagged using a polyvinyl chloride flag with a unique identifier number recorded in indelible ink. The location will be flagged 1 foot north of the actual field location of each reacquired anomaly indicated on the tracking sheet.

Intrusive Investigation

Excavation of individual geophysical anomalies will be performed by qualified UXO technicians using hand-excavation tools to a maximum depth of 2 feet. The UXO teams performing this work will be composed of at least one UXO Technician II and up to four UXO Technicians II or I supervised by a UXO Technician III. Details associated with this operation are included in the MEC Removal SOP (**Attachment 1**).

Hand tools will be used for the majority of the items, which generally are expected to be found near the surface. The following basic technique will be used for anomaly excavation:

- The UXO technician will investigate 1 foot south of the emplaced flag with the assistance of a Schonstedt GA-52CX, White's XLT all-metals detector or equivalent, within a 1-meter radius to pinpoint the anomaly source.
- Until identified otherwise, each anomaly is assumed to be MEC. Excavation will be initiated adjacent to the subsurface anomaly. The excavation will continue until the excavated area has reached a depth below the top of the anomaly as determined by frequent inspection with an appropriate geophysical instrument.
- Using progressively smaller and more delicate tools to remove the soil carefully, the excavation team will expand the sidewall to expose the metallic item for inspection and identification without moving or disturbing the item.
- Once the item is exposed for inspection, the excavation team will determine whether the item is MEC, MPPEH, or other debris.

If the item is MEC, a positive identification will be documented and confirmed by a second UXO technician. If 3.5-inch rockets, or other MEC/MPPEH, are found in multiple locations during a single workday, up to five items may be consolidated within the site for treatment, in accordance with the ESS (ESS-104) (CH2M HILL, 2009a), ESS

Amendment No. 1 (ESS-107) (CH2M HILL 2009b), and ESS Amendment No. 3 (ESS-120) (CH2M HILL, 2010). If MEC/MPPEH is determined safe to move (as confirmed by the Senior Unexploded Ordnance Supervisor [SUXOS] and Unexploded Ordnance Safety Officer [UXOSO]), the MEC may be moved for controlled detonation and/or consolidation. All other MEC will be destroyed using BIP procedures.

In determining whether MEC/MPPEH items are safe to move, the SUXOS and UXOSO must determine that the risk associated with movement is acceptable and that the movement is necessary for the efficiency of the activities being conducted or the protection of people, property, or critical assets. In such cases, the responsible SUXOS and UXOSO must agree with the risk determination and document this decision in writing prior to movement of the MEC.UXO-qualified personnel may determine that MPPEH is safe for onsite movement. Written documentation and concurrence of the UXOSO is not required for MPPEH.

Following demolition/removal of the MEC item, MPPEH, or other debris, the area will be rechecked with an EM61-MK2 to ensure that another item was not hidden beneath the removed item or is otherwise remaining within the excavation. The excavation team will then record the results of the excavation, backfill the hole, and move on to the next marked subsurface anomaly location.

If the item is other debris, it will be collected and segregated from MPPEH.

If the item is MPPEH, the procedures presented in Section 4.5 will be followed.

3.2 Removal Verification

3.2.1 DGM Transects

Upon completion of the intrusive investigation of all selected anomalies (or targets) within a transect or group of transects completed by DGM, the Unexploded Ordnance Quality Control Specialist (UXOQCS) will perform a QC check on a minimum of 10 percent of the selected targets. The project geophysicist or the Site Manager (SM) will provide the UXOQCS with a list of all the targets that will be verified through QC. The UXOQCS will inspect each target using an EM61-MK2 (the same type of geophysical device used for DGM). The UXOQCS will use the EM61-MK2 to observe the strength of the geophysical response at the coordinates of the target and whether the location was cleared to background levels established for the site. If the strength of the geophysical response is appropriate for the site background then the QC inspection for that location is complete. If the geophysical response is greater than background, then the UXOQCS will inspect a 1-meter radius around the target coordinates using an EM61-MK2, and if needed a handheld metals detector (Schonstedt GA-52Cx or equivalent). Hand digging will be conducted at all locations where the presence of buried metals is indicated. The UXOQCS will record the results of all items that are recovered during the QC inspection. If any pieces of metal that are 1 square inch are recovered, that will be considered a QC failure of the transect and a Root-Cause Analysis will be initiated. The dig team will re-investigate all targets within a transect or group of transects where a QC failure has occurred and the QC process will be repeated for the transect or group of transects.

3.3 Procedures for Reporting and Disposition of MEC and MPPEH Items

This section discusses the procedures for reporting and disposing of MEC and MPPEH items encountered during the project, including the responsibilities of personnel, overall safety precautions, data reporting, transportation, safe holding areas, operations in populated areas, demolition operations, and required engineering controls and exclusion zones (EZs) for intrusive operations and intentional detonations. The general responsibilities of project personnel are described in Section 2.5 of the MRP MPP (CH2M HILL, 2008).

3.3.1 Overall Safety Precautions

The overall safety precautions described in Section 2.5.1 of the MRP MPP (CH2M HILL, 2008) will be adhered to during the intrusive investigation.

Qualified UXO personnel will dispose of all MEC items (including MPPEH if necessary) using explosive demolition procedures by countercharging these items with an explosive donor charge and detonating the donor charge. This

will be performed by a demolition team consisting of one UXO Technician III as the Demolition Supervisor and two UXO Technician II personnel, with the SUXOS responsible for the operation.

3.3.2 Data Reporting

Data reporting for each geophysical anomaly will be done in accordance with Section 2.5.2 of the MRP MPP (CH2M HILL, 2008).

3.3.3 Operations in Populated and Sensitive Areas

There are populated areas northeast and south of the site that could be impacted by intrusive operations. If the unintentional detonation minimum separation distance for public and non-essential personnel during MEC intrusive operations impacts roadways, the SM will coordinate with Base operations to implement traffic controls. Such controls may include temporarily closing roads or interrupting intrusive operations when vehicular and pedestrian traffic is present.

The EZ for intentional detonation will be determined for each detonation operation. If an inhabited building is impacted, the demolition team will attempt to mitigate this impact through the use of engineering controls. If engineering controls do not adequately reduce the EZ, the SM will coordinate with Base operations to evacuate the inhabited buildings. If possible, demolition operations will be performed after regular building occupation hours.

No sensitive habitats are anticipated to be encountered within the MRS; however, if sensitive habitats are identified, MEC operations in these areas will be conducted in accordance with the Environmental Protection Plan presented in the *Sampling and Analysis Plan (Field Sampling Plan and Quality Assurance Project Plan) Preliminary Assessment/Site Inspection; Military Munitions Response Program Site UXO-22 – Former Munitions Disposal Area, MCIEAST-CAMLEJ, North Carolina* (CH2M HILL, 2012) to be protective of these sensitive areas. No threatened and endangered species or their habitats are known to be present within the site boundaries (CH2M HILL, 2012).

3.3.4 Exclusion Zones and Separation Distance

MR activities within Site UXO-22 are covered by the existing Site UXO-22 ESS (ESS-120) (CH2M HILL, 2010). If any discrepancies exist between this TMP and the ESS, the ESS will govern. Based on the munitions identified at the site during previous investigations, the Projectile 81-millimeter (mm) high explosive (HE) M43 will be used for the primary munitions with the greatest fragmentation distance (MGFD). The Explosives Safety Quantity Distance arcs for the primary MGFD is presented on **Figure 3-1**.

The EZ for the primary MGFD for the MRS are presented in **Table 3-1**. If fragmenting MEC is found with a larger MGFD, work at the site will stop and an ESS amendment will be submitted for the MRS to incorporate the change in MGFD.

3.3.5 MEC and MPPEH Hazards Classification, Storage, and Transportation

MEC and MPPEH will be classified and transported as discussed in Section 2.6 of the MRP MPP (CH2M HILL, 2008). MEC will not be stored onsite, but will rather be stored at the MPPEH Collection Point specified in the applicable ESS and stored as discussed in Section 2.6 of the MRP MPP (CH2M HILL, 2008). All MEC/MPPEH will be classified as class/division 1.1. MEC and MPPEH will not be transported offsite.

A systematic approach will be used for collecting, inspecting, and segregating site debris. The approach is designed so that materials will undergo a continual evaluation/inspection process from the time they are acquired until the time they are removed from the site. Segregation procedures begin at the time the item is discovered by the UXO technician. At this point, the UXO technician makes a preliminary determination as to the classification of the item into one of three categories, and the UXO Technician III confirms the item to be MEC, MPPEH, or other debris.

MPPEH that has undergone two 100 percent visual inspections by two UXO Technician IIIs who are independent of each other in the reporting chain and are authorized to sign the Requisition System Document DD Form 1348-1A as not presenting an explosive hazard will be considered to be MDAS. MDAS will be stored in a

locked container at least 50 feet from the MPPEH collection point. MDAS and other debris may be transported offsite via a DD Form 1348-1A.

3.3.6 MEC Disposition

MEC and MPPEH will be demilitarized by BIP methods or may be relocated for demolition if the items are determined safe for movement by the SUXOS and UXOSO.

3.3.7 MPPEH Disposition

MPPEH will be visually inspected and independently re-inspected for explosive hazards as discussed in Section 2.7.2 of the MRP MPP (CH2M HILL, 2008). MPPEH that cannot be classified as MDAS will be disposed of in the same manner as MEC.

3.3.8 Recording, Reporting, and Implementation of Lessons Learned during the Project

Lessons learned will be performed in accordance with Section 2.7 of the MRP MPP (CH2M HILL, 2008).

3.4 Demobilization

Full demobilization will occur when the project is completed and appropriate QA/QC checks have been performed. Personnel who are no longer needed during the course of field operations may be demobilized prior to the final project completion date. The following will occur prior to demobilization:

- All areas to be investigated will be verified as completed.
- Restoration of the site to an appropriate condition will be verified.
- All equipment will be inspected, packaged, and shipped to the appropriate location.
- All facilities-support infrastructures will be dismantled and shipped to the appropriate location, and the field site will be returned to the original condition prior to mobilization.

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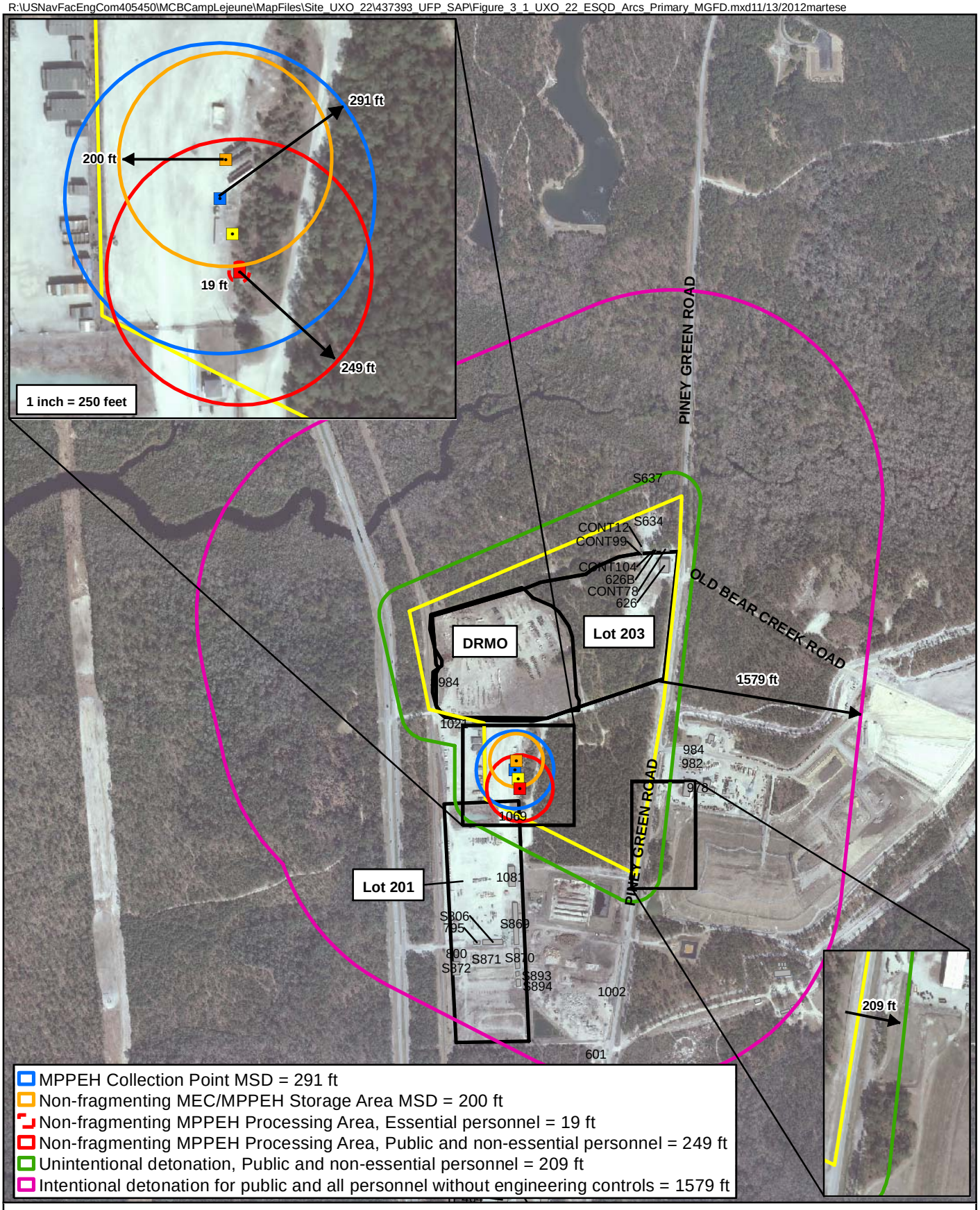

Legend

- MEC/MPPEH Storage Area, ATF Type II Magazine
- Non-Fragmenting MPPEH Processing Area
- MDAS Collection Point
- MPPEH Collection Point
- UXO-22 Boundary

N

0 500 1,000 Feet

1 inch = 1,000 feet

Figure 3-1
Explosive Safety Quantity Distance (ESQD) Arcs
for Primary MGFD (81 mm HE M43 projectile)
Site UXO-22 UFP-SAP
MCIEAST-MCB CAMLEJ
North Carolina

CH2MHILL

SECTION 4

Explosives Management Plan

The management of on-call explosives to support disposal of potential MEC and MPPEH items discovered during the investigation will be done in accordance with Section 3 of the MRP MPP (CH2M HILL, 2008).

SECTION 5

Explosives Siting Plan

Explosives safety criteria for planning and siting explosives operations for MEC/MPPEH disposal are provided in Section 4 of the MRP MPP (CH2M HILL, 2008). There are no planned or established MEC detonation areas. MEC that is safe to move may be consolidated for demolition (in accordance with the applicable ESS); otherwise, MEC will be BIP where it is found. MPPEH that cannot be certified and verified as "safe to move" will remain at location of discovery and will be treated in the same manner as MEC.

SECTION 6

Environmental Protection Plan

6.1 Regional Ecological Summary

A summary of the regional ecology is provided in Section 9.1 of the MRP MPPs (CH2M HILL, 2008).

6.2 Endangered/Threatened Species within the Project Site

Many protected species have been sighted in the vicinity of and aboard MCIEAST–MCB CAMLEJ, such as American alligator, green sea turtle, loggerhead sea turtle, piping plover, red-cockaded woodpecker (RCW), seabeach amaranth, and rough-leaf loosestrife (USMC, 2006). **Table 6-1** lists those species that could occur in or adjacent to MCIEAST–MCB CAMLEJ that are listed as threatened, endangered, or of special concern by the United States Fish and Wildlife Service (USFWS) under the Endangered Species Act of 1973, as amended.

MCIEAST–MCB CAMLEJ has active programs in place to protect the two federally protected avian species (piping plover and RCW) that are known to occur on the Base. UXO-22 is not within the vicinity of any of these management areas. Suitable habitat for the piping plover does not exist at UXO-22. No impacts to this species would result.

MCIEAST–MCB CAMLEJ worked with the USFWS to establish guidelines for military training in RCW cluster sites. Additionally, through Section 7 Consultation, the Base implemented measures to properly manage the RCW habitats located on the Base (loblolly pine [*Pinus taeda*], longleaf [*Pinus palustris*], and pond pine [*Pinus serotina*] areas). These guidelines and measures are presented in the 2007 through 2011 Integrated Natural Resource Management Plan (INRMP) (USMC, 2006). MCIEAST–MCB CAMLEJ's RCW population has been monitored since 1985. Reproductive success, population demographics, and habitat use are recorded annually to help successfully manage the population while facilitating the military use of the land. UXO-22 is not within the vicinity of any current RCW management areas, and the closest active RCW habitat is located approximately 0.7 mile east of the site. No impacts to this species would result.

UXO-22 contains no open water habitat and does not connect to the ocean. Therefore, the federally protected marine species (green sea turtle, leatherback sea turtle, loggerhead sea turtle, and West Indian manatee) listed in **Table 6-1** would not occur the area. No impacts to these species would result.

The American alligator is listed on the Federal Threatened and Endangered species list due to its similarity of appearance to the American crocodile. There is no potentially suitable habitat for the American alligator in UXO-22 investigation area and the species would not occur in the project area. No impact to this species is expected.

Two of the five federally listed plant species identified in **Table 6-1** have been identified on the Base: rough-leaved loosestrife and seabeach amaranth. Approximately 22 rough-leaved loosestrife sites are found on MCIEAST–MCB CAMLEJ, with 76 acres buffered and marked to protect this species. Rough-leaved loosestrife sites are visited annually to visually inspect for changes in extent and apparent health. Approximately half of the rough-leaved loosestrife sites occur within protected RCW sites, obviating the need for marking each of these sites individually. The other sites, mostly falling within the Greater Sandy Run Area are marked with white paint around a perimeter that extends 100 feet from the outermost individuals. None of these sites are located on or adjacent to UXO-22. No impacts to rough-leaved loosestrife are expected.

Seabeach amaranth is an annual that has been described as a dune-builder because it frequently occupies areas seaward of primary dunes often growing closer to the high tide line than any other coastal plant. As such, this plant is generally found along Onslow Beach. Seabeach amaranth does not occur on or adjacent to UXO-22 because there is no beach or dune habitat. No impacts to this species would occur.

The eastern cougar is the only federally listed mammal species that could occur in Onslow County. The only extant population of eastern cougar is located in south Florida and the species has not been observed in North Carolina in over 50 years. Suitable habitat for the eastern cougar does not exist at UXO-22 and the level of human activity would tend to make the species avoid the area. Because the eastern cougar has not been verified in the area in more than 50 years and there is human activity at UXO-22, it is very unlikely that the eastern cougar would occur on the site and no impacts are expected.

Environmental reviews completed in preparation for the INRMP determined that the remaining species listed in **Table 6-1** are not expected to exist at the site. No adverse impacts to listed species are expected to result from the proposed work at UXO-22. Project design features have been developed to prevent impacts to listed species.

6.3 Wetlands within the Project Site

There are no jurisdictional wetland areas within UXO-22.

6.4 Cultural and Archaeological Resources within the Project Site

The probability that any significant cultural or archeological resources will be impacted by the field investigation is low. Consultation with the Base archaeologist confirmed that no cultural or archaeological resource is known to lie within the UXO-22 boundary. If any unmapped cultural or archaeological materials or resources are discovered within the project investigation area, the Base archaeologist will be notified to provide guidance on performing further work in the area.

6.5 Water Resources within the Project Site

Wallace Creek occurs near the northern end of UXO-22, and Bear Head Creek crosses the southern portion of the site. No water resources are expected to be impacted by the project.

6.6 Vegetation to be removed within the Project Site

Limited vegetation removal may be performed at the site to access DGM transects and geophysical anomalies. Only vegetation less than 6 inches in diameter will be cut to within 6 inches of ground surface. Consultation with the Base wildlife biologist confirms no threatened or endangered species have been located within the project area.

6.7 Existing Waste Disposal Sites within the Project Site

Historically, UXO-22 was used for disposal and storage of wastes and supplies, including pesticides transformers containing polychlorinated biphenyls, solvents, electrolytes, and waste oils. Currently, Lot 201 is used to store military equipment, vehicles, hydraulic oils, and other “non-hazardous” supplies. Lot 203 is used by the Defense Reutilization Marketing Office as a scrap and surplus storage lot. As part of the CERCLA process at this site, soil intrusive land use controls (LUCs) are currently in place in order to reduce worker exposure to potential soil contamination. As required by the LUCs, standard level D personal protective gear will be used by workers disturbing the ground surface.

6.8 Compliance with Applicable or Relevant and Appropriate Requirements

CH2M HILL will follow all applicable regulations concerning environmental protection, pollution control, and abatement for the proposed project work as described in Section 9.3 of the MRP MPPs (CH2M HILL, 2008). No permits have been determined to be required for the proposed work.

6.9 Detailed Procedures and Methods to Protect and/or Mitigate the Resources/Sites Identified

During the proposed work, a general survey of the project area will be conducted by the field personnel to identify obvious environmental concerns. The Project Manager (PM), in conjunction with a qualified ecologist, will provide instructions to field personnel regarding the protection of onsite environmental resources. Such protective measures will include, but are not limited to, the following:

- Should a federally protected plant species be identified within the project area, specimens will be flagged for easy relocation and verification
- Should cultural or archaeological material or resources be discovered within the project area, the Base archaeologist will be notified to provide guidance on performing further work in the area

The PM will seek the guidance of a qualified ecologist to determine appropriate mitigation measures in the event that the performed work activities impact an environmental resource

TABLE 6-1
Species Potentially Occurring on or Adjacent to MCIEAST–MCB CAMLEJ, in Onslow County, Listed as Threatened, Endangered, or of Special Concern by the USFWS

Scientific Name	Common Name	Federal Status	Habitat
Anguilla rostrata	American eel	FSC	The American eel is catadromous; it spawns in oceanic waters but uses freshwater, brackish and estuarine systems for most of its developmental life. Migrates in autumn to the Sargasso Sea to spawn. Occurs usually in permanent streams with continuous flow. Hides during the day in undercut banks and in deep pools near logs and boulders.
Chelonia mydas	Green sea turtle	T	Green turtles are generally found in fairly shallow waters (except when migrating) inside reefs, bays, and inlets. The turtles are attracted to lagoons and shoals with an abundance of marine grass and algae. Open beaches with a sloping platform and minimal disturbance are required for nesting.
Caretta caretta	Loggerhead sea turtle	T	The loggerhead is widely distributed within its range. It may be found hundreds of miles out to sea, as well as in inshore areas such as bays, lagoons, salt marshes, creeks, ship channels, and the mouths of large rivers.
Dermochelys coriacea	Leatherback sea turtle	E	An open ocean species, it sometimes moves into shallow bays, estuaries and even river mouths.
Trichechus manatus	West Indian Manatee	E	Manatees inhabit both salt and fresh water of sufficient depth (1.5 meters to usually less than 6 meters) throughout their range.
Alligator mississippiensis	American alligator	T(S/A)	Rivers, swamps, estuaries, lakes, and marshes
Charadrius melodus	Piping plover	T	Open, sandy beaches close to the primary dune of the barrier islands and coastlines of the Atlantic for breeding. They prefer sparsely vegetated open sand, gravel, or cobble for a nest site. They forage along the rack line where the tide washes up onto the beach.
Aimophila aestivalis	Bachman's sparrow	FSC	Occurs only in pine forests of the southeastern U.S.
Haliaeetus leucocephalus	American bald eagle	T	A single bald eagle's nest is found on Camp Lejeune- at the junction of Sneads Creek and the New River near the back gate. Three protective buffers have been established at approximately 750', 1000', and 1500' from the nest site.
Laterallus jamaicensis	Black rail	FSC	Marsh/wetlands; The "Eastern" Black Rail can be found in appropriate saltmarsh habitat along the eastern seaboard from Connecticut to Florida and along the Gulf Coast.
Acipenser brevirostrum	Shortnose sturgeon	E	Sturgeon inhabits the lower sections of larger rivers and coastal waters along the Atlantic coast. It may spend most of the year in brackish or salt water and move into fresh water only to spawn. The fish feeds on invertebrates (shrimp, worms, etc.) and stems and leaves of macrophytes.
Rana capito capito	Carolina crawfish frog	FSC	Carolina crawfish frogs live primarily in the sandhills and pine barrens of the North Carolina Coastal Plain. Crawfish frogs are more terrestrial than most frogs, generally only coming to the water to breed. They are also nocturnal, spending daylight hours underground in burrows.

TABLE 6-1
Species Potentially Occurring on or Adjacent to MCIEAST–MCB CAMLEJ, in Onslow County, Listed as Threatened, Endangered, or of Special Concern by the USFWS

Scientific Name	Common Name	Federal Status	Habitat
Puma concolor couguar	Eastern cougar	E	No preference for specific habitat types has been noted. The primary need is apparently for a large wilderness area with an adequate food supply. Male cougars of other subspecies have been observed to occupy a range of 25 or more square miles, and females from 5 to 20 square miles.
Passerina ciris ciris	Eastern painted bunting	FSC*	Found mainly in southern states and Mexico, where the brushy, weedy shrub-scrub habitat that this bird prefers abound
Ammodramus henslowii	Eastern Henslow's sparrow	FSC	A species of tallgrass prairies, agricultural grasslands, and pine savannas of the eastern U.S.; the species migrates south to spend the non-breeding season in the native pine savanna habitats of the southeastern U.S.
Ophisaurus mimicus	Mimic glass lizard	FSC	This species is found in the southeastern Coastal Plain. They are most common in pine flatwoods and open woodlands.
Picoides borealis	Red-cockaded Woodpecker	E	For nesting/roosting habitat, open stands of pine containing trees 60 years old and older. Red-cockaded woodpeckers need live, older pines in which to excavate their cavities. Longleaf pines (Pinus palustris) are most commonly used, but other species of southern pine are also acceptable. Dense stands (stands that are primarily hardwoods, or that have a dense hardwood understory) are avoided. Foraging habitat is provided in pine and pine hardwood stands 30 years old or older with foraging preference for pine trees 10 inches or larger in diameter. In good, moderately-stocked, pine habitat, sufficient foraging substrate can be provided on 80 to 125 acres.
Heterodon simus	Southern hognose snake	FSC	These snakes are found in sandy fields and woods of the Coastal Plain, particularly in the Sandhills region.
Agrotis buchholzi	Buchholz's dart moth	FSC	Found in Forested wetlands, scrub-shrub wetlands, shrubland/ chaparral and coniferous woodlands. This moth is found mostly in recently burned habitats. Populations can persist up to about a decade or rarely two without fire, until litter accumulates sufficiently to cover foodplants. In most cases habitat is probably suboptimal beginning about 5 years after a fire.
Atrytonopsis sp.	a skipper	FSC	One species, the dusteds are fairly rare at the coast but found throughout North Carolina (*A. hianna*). An assumption is made that the genius is generally defined.
Isoetes microvela	A quillwort	FSC	Quillworts are usually restricted to areas of clean water where other plants are absent. Occasionally, quilwort may grow partly or entirely out of the water.
Rhexia aristosa	Awned meadowbeauty	FSC	Found in a variety of wet habitats in the Coastal Plain from New Jersey to Alabama.
Lobelia boykinii	Boykin's lobelia	FSC	Grows in swamps and cypress ponds from the coastal plain of Delaware to Florida. The lower portion is often immersed in water, at least seasonally.
Solidago pulchra	Coastal goldenrod	FSC	Bogs, freshwater habitats, grasslands.
Parnassia caroliniana	Carolina grass-of-parnassus	FSC	Bogs, freshwater habitats, grasslands.

TABLE 6-1
Species Potentially Occurring on or Adjacent to MCIEAST–MCB CAMLEJ, in Onslow County, Listed as Threatened, Endangered, or of Special Concern by the USFWS

Scientific Name	Common Name	Federal Status	Habitat
Trillium pusillum var. pusillum	Carolina trillium	FSC	Grows in alluvial woods, pocosin borders and savannahs.
Asplenium heteroresiliens	Carolina (wagner) spleenwort	FSC	Rock outcrops.
Rhynchospora pleiantha	Coastal beaksedge	FSC	Extremely rare, found at fewer than 25 sites throughout its North Carolina-to-Alabama range.
Solidago villosicarpa	Coastal Goldenrod	FSC	Known to occur in only 5 populations in three counties in eastern North Carolina. Three of these populations occur on Camp Lejeune. The other sites occur in Pender and Brunswick Counties. Currently the North Carolina Natural Heritage Program is conducting a survey of likely habitat to look for coastal goldenrod.
Thalictrum cooleyi	Cooley's meadowrue	E	Cooley's meadowrue occurs in moist to wet bogs and savannahs. It grows along fireplow lines, roadside ditches, woodland clearings, and powerline rights-of-way, and needs some type of disturbance to maintain its open habitat.
Carex lutea	Golden sedge	E	Biologists have located golden sedge in only eight locations, all in coastal savannas in Onslow and Pender Counties that are underlain by calcareous, or chalk, deposits.
Sagittaria weatherbiana	Grassleaf arrowhead	FSC	Found in shallow water of brackish swamps
Dichanthelium sp.	Hirst's panic grass	FSC	Worldwide, Hirst's panic grass occurs in four extant populations. Historically, it was found in coastal plain habitats in the states of New Jersey, Delaware, North Carolina and Georgia. Currently Hirst's panic grass is known to exist in one site in Delaware and two known sites in North Carolina, both of which are on Camp Lejeune.
Myriophyllum laxum	Loose watermilfoil	FSC	Riparian habitats.
Calopogon multiflorus	Many-flower grass-pink	FSC	Grasslands, pinelands; typically in wet areas.
Plantago sparsiflora	Pineland plantain	FSC	Savannahs, roadsides and ditches.
Lindera melissifolia	Pondberry	E	Associated with wetland habitats such as bottomland and hardwoods in the interior areas, and the margins of sinks, ponds and other depressions in the more coastal sites. The plants generally grow in shaded areas but may also be found in full sun.
Litsea aestivalis	Pondspice	FSC	Freshwater habitats.
Lysimachia asperulaefolia	Rough-leaved loosestrife	E	Species generally occurs in the ecotones or edges between longleaf pine uplands and pond pine pocosins (areas of dense shrub and vine growth usually on a wet, peaty, poorly drained soil), on moist to seasonally saturated sands and on shallow organic soils overlaying sand. Rough-leaved loosestrife has also been found on deep peat in the low shrub community of large Carolina bays
Amaranthus pumilus	Seabeach amaranth	T	Occurs on barrier island beaches.
Allium sp.	Savanna onion	FSC	Wet savannahs.
Scleria sp.	Smooth-seeded hairy nutrush	FSC	Dry woods, pineland and savannahs (*S. triglomerata*)

TABLE 6-1
Species Potentially Occurring on or Adjacent to MCIEAST–MCB CAMLEJ, in Onslow County, Listed as Threatened, Endangered, or of Special Concern by the USFWS

Scientific Name	Common Name	Federal Status	Habitat
Rhynchospora decurrens	Swamp forest beakrush	FSC	Swamp forests, very rare.
Solidago verna	Spring-flowering goldenrod	FSC	The only spring-flowering goldenrod that occurs in the Sandhills and Coastal Plain of the Carolinas. It can be found in a wide array of habitats, including pine savannas, pocosins, and pine barrens.
Rhynchospora thornei	Thorne's beaksedge	FSC	Bogs, freshwater habitats, pinelands.
Dionea muscipula	Venus flytrap	FSC	Bogs, pinelands.

E = Endangered—A taxon in danger of extinction throughout all or a significant portion of its range.

T = Threatened—A taxon likely to become endangered within the foreseeable future throughout all or a significant portion of its range.

FSC = Federal species of special concern—species may or may not be listed in the future.

T(S/A)—Threatened due to similarity of appearance (e.g., American alligator)--a species that is threatened due to similarity of appearance with other rare species and is listed for its protection. These species are not biologically endangered or threatened and are not subject to Section 7 consultation.

*Historic record—the species was last observed in the county more than 50 years ago.

SECTION 7

References

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Attachment 1
MEC Removal Standard Operating Procedures

The selected subcontractor's munitions and explosives of concern (MEC) removal standard operating procedure (SOP) will be provided in this Appendix upon completion of the procurement process.

Appendix B
Geophysical Investigation Plan

Appendix B

Geophysical Investigation Plan
UXO-22 – Former Munitions Disposal Area

Marine Corps Installations East- Marine Corps Base Camp Lejeune, North Carolina

Contract Task Order WE54

August 2013

Prepared for

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Mid-Atlantic

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Prepared by

CH2MHILL

Charlotte, North Carolina

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Acronyms and Abbreviations

bgs	below ground surface
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act of 1980
DGM	digital geophysical mapping
DRMO	Defense Reutilization and Marketing Office
FTP	File Transfer Protocol
GDB	Geosoft database
GIP	Geophysical Investigation Plan
GSV	Geophysical System Verification
ID	identification
IRP	Installation Restoration Program
ISO	industry standard object
MC	munitions constituents
MCIEAST–MCB CAMLEJ	Marine Corps Installations East–Marine Corps Base Camp Lejeune
MDAS	material documented as safe
MEC	munitions and explosives of concern
mm	millimeter
MPPEH	material potentially presenting an explosive hazard
MQO	Measurement Quality Objective
MRSIMS	Munitions Response Site Information Management System
mV	millivolt
NAD83	North American Datum 1983
NAVFAC	Naval Facilities Engineering Command
OU	Operable Unit
PA/SI	Preliminary Assessment/Site Inspection
PDF	Portable Document Format
QC	quality control
RI	Remedial Investigation
UTM	Universal Transverse Mercator
UXO	unexploded ordnance

Geophysical Investigation Plan

This Geophysical Investigation Plan (GIP) presents the objectives, site background, approach, geophysical operational procedures, and quality control (QC) methods to be used to prepare for and perform digital geophysical mapping (DGM) at Marine Corps Installations East–Marine Corps Base Camp Lejeune (MCIEAST–MCB CAMLEJ) in Jacksonville, North Carolina. DGM will be performed at Site Unexploded Ordnance (UXO) 22 – Former Munitions Disposal Area.

This GIP was prepared on behalf of the Department of the Navy, Naval Facilities Engineering Command (NAVFAC) Mid-Atlantic, under Contract Number N62470-11-D-8012, Contract Task Order (CTO) WE54.

1. Project Objective

The DGM will be conducted in support of a Remedial Investigation (RI). The objective of the RI is to characterize the nature and extent of potential munitions and explosives of concern (MEC) and material potentially presenting an explosive hazard (MPPEH). DGM will be conducted to identify geophysical anomalies that may be indicative of potential MEC and MPPEH.

2. Site Description

Site UXO-22 covers an area of approximately 75 acres between Piney Green Road and Holcomb Boulevard at MCIEAST–MCB CAMLEJ. The Site UXO-22 boundary is outlined in yellow on **Figure 1**. The site is composed of portions of Operable Unit (OU) 2, Site 6, and Site 82, which have undergone investigation and remediation associated with non-munitions constituents (MC) under the Installation Restoration Program (IRP). Access is restricted to military personnel and civilians authorized to enter the Base. Access is also restricted through the use of land use control boundaries for Sites 6 and 82.

Previous environmental investigations have been conducted at OU2, Site 6, and Site 82 since 1983. CH2M HILL conducted a Preliminary Assessment /Site Inspection (PA/SI) at UXO-22 between December 2011 and March 2012 as the first step in MCIEAST–MCB CAMLEJ investigating closed ranges and munitions disposal areas at the Base following the Comprehensive Environmental Response, Compensation, and Liability Act of 1980 (CERCLA) process.

The *Draft Preliminary Assessment/Site Inspection Report, Site UXO-22, Former Munitions Disposal Area* (CH2M HILL, 2012) states that the earliest documented land use at UXO-22 is from archival aerial photography taken in 1948 that shows cleared land, the unnamed road between Holcomb Boulevard and Piney Green Road, and areas of re-worked earth. Subsequent photographs and maps reveal the presence of structures in the 1960s that are no longer in existence. Historically, these areas of re-worked earth at Site UXO-22 were used for storage and disposal of wastes and supplies, including pesticides, transformers containing polychlorinated biphenyls, solvents, electrolytes, waste oils, batteries, and undocumented discard military munitions. Lot 201 is currently used to store military equipment, vehicles, hydraulic oils, and other non-hazardous supplies. The western portion of Lot 203 is an open field, with 21 acres formerly used from 2001 through 2012 by the Defense Reutilization and Marketing Office (DRMO) as a temporary scrap and surplus storage lot.

No former range activities are known to have occurred at the site.

FIGURE 1
UXO-22 Site Location

3. Anticipated MEC Types and Quantities

MEC and MPPEH have been discovered during previous investigation and remediation activities at Site UXO-22. As a result, Site UXO-22 was established under the Military Munitions Response Program. The following list contains the MEC and MPPEH found during previous investigations conducted under the IRP. Quantities of each item indicated in parentheses.

The following MEC items have been recovered, inspected, re-inspected, and classified as material documented as safe (MDAS) during previous investigations:

- Mortar Shell, 81-millimeter (mm), high explosive, M43 with fuze M45 (1)
- Mortar Shell, 60-mm, high explosive, M49 without fuze (1)
- Rocket, 3.5-inch, high explosive anti-tank, M28 (1)
- MK II grenades (4)
- MK II hand grenade (1)

The following MPPEH items were recovered, inspected, re-inspected, and classified as MDAS during previous investigations:

- M-2 Antipersonnel, mine, bounding (4)
- 57-mm brass cartridges (5)
- M-29 Rocket, practice warhead only (22)
- Rocket motors, 3.5-inch expended (40)
- M-29 Rocket, 3.5-inch with M-405 Fuze (5)
- M-29 rockets, practice warhead only (39)
- M-29 rocket motors, 3.5-inch, model unknown (52)
- Stabilizer assemblies, M9 AT, rifle grenades (2)
- Grenades, practice, MK21, empty (2)
- Warheads for rockets, 3.5-inch, model unknown (8)
- Rocket fuzes, 3.5-inch, model unknown (3)
- 3.5-inch rockets believed to be M29 practice (22)
- 3.5-inch rocket fuzes believed to be practice (49)
- MK21 practice hand grenades (42)
- M45 mortar fuze, expended (1)
- Mortar shells, 60-mm, practice, M50A2 (4)
- Rocket motors (1,500)
- M48 trip flares (empty), practice (8)
- Full and partial 105-mm shipping containers (10)
- Empty 105-mm cartridge (1)
- Empty 75-mm recoilless rifle cartridge (1)
- 3.5-inch rocket warhead, practice (1)
- Empty shipping containers (6)
- 3.5-inch practice rocket (1)
- 3.5-inch rocket motors (3)
- 105/106-mm cartridges (1)
- 105/106-mm cartridges, expended (8)
- 105/106-mm (1)
- 105/106-mm ammunition components (1)
- 95-mm casings (1)
- Shell casings (1)
- 40-mm practice projectiles (100)
- 40-mm cartridges (200)
- 40-mm rocket cartridge (1)
- 75-mm fragments (1)
- 75-mm cartridges, propellant canister (1)
- 30-mm and 40-mm ammunition, expended (1)
- 30-mm and 40-mm cartridges, expended (1)
- .50-caliber cartridge, expended (1)
- Munitions debris, spent casings (3)
- 7.62-mm ammunition (1)
- M27A1 signal illuminating ground flares (6)
- Mark 13 grenade diversionary (2)
- 3.5-inch rocket motors/parts (6)
- 30-mm cartridge (1)

4. Vegetation and Topography

The surface topography within the central and southern portions of Site UXO-22 is generally level and slopes gently toward Wallace Creek in the northern portion of the site. A narrow, ephemeral drainage feature runs from the north-central portion of the site and trends northwest to Wallace Creek. Vegetation ranges from coniferous woodland to open grass and dirt-covered areas.

5. Geologic Conditions

Geologic conditions are generally a concern for DGM when the mineral content of rocks and soils is significant enough to produce anomalies consistent with potential MEC. In particular, these conditions are a greater concern when using magnetometers to conduct surface sweeps or to collect DGM data compared to electromagnetic or other geophysical instruments

Site UXO-22 is underlain by light-colored, fine-grained sands extending to depths of at least 50 feet below ground surface (bgs), with discontinuous silty or clayey sand lenses occurring at depths from 10 to 50 feet bgs. The shallow subsurface (that is, upper 20 feet) has been disturbed at select locations at the site due to previous excavation and dumping activities. In addition, a layer of burned material is encountered at depths less than 5 feet bgs throughout much of the central portion of the site encompassing the former DRMO. It is assumed that these geologic conditions will not significantly impact proposed DGM.

6. Shallow Groundwater Conditions

Depth to groundwater ranges from 4 feet bgs in the south to 17 feet bgs in the north. Localized groundwater conditions may present potential access issues or safety hazards if the survey area is prone to standing water during periods of heavy precipitation. In addition, site-specific groundwater conditions (such as depth to water table and salinity) may result in variations of geophysical response signatures of potential MEC items compared to predicted or theoretical responses if the items are susceptible to enhanced corrosion or deterioration due to local groundwater fluctuations and conditions. For the DGM at Site UXO-22, the groundwater conditions are unlikely to impact proposed DGM and because DGM has been successfully completed elsewhere at the installation.

7. Adverse Geophysical Conditions

Potential adverse conditions include the presence of surface metal across the area of Site UXO-22 encompassing the former DRMO. These effects may result in a localized increase in the number of anomalies and potential inability to select individual, discrete anomalies.

In addition, vegetation would only be cleared to within 6 inches of the ground surface, resulting in potentially uneven terrain along a portion of the transects. Such conditions may result in increased noise in the DGM data due to instrument bounce as the DGM system moves along the DGM transects. The DGM subcontractor will make a determination in the field as to how to deploy the system in order to minimize the effects of terrain-induced noise.

8. Site Utilities

CH2M HILL will review available underground utility maps from MCIEAST–MCB CAMLEJ to evaluate the presence of potential underground utilities within the proposed DGM area. Because of the proximity of the DGM areas to Holcomb Boulevard and Piney Green Road, as well as the long history of the site (which included previous aboveground structures in the 1960s), active and abandoned underground utilities may be present within the general area. Electronic files or maps that can be obtained by CH2M HILL from the installation will be used, to the extent possible, as overlays on the DGM data in order to assist with interpretation of the DGM results.

9. Man-made Features Potentially Affecting DGM Operations

Man-made features that would potentially impact DGM operations include surface metal debris scattered across the site within the former DRMO, as well as military equipment, other equipment, and storage containers staged at the former DRMO, within Lots 201 and 203, or elsewhere within the site boundary.

10. Overall Site Accessibility and Impediments

The former DRMO area is maintained within a locked fence area, so work within this area will have to be coordinated with the installation. Otherwise, there are no expected site accessibility impediments. No substantial delays due to abnormally harsh weather conditions are expected to impact the DGM operations, although periods of heavy rain or other localized weather patterns at the time of DGM may result in temporary inaccessible conditions. CH2M HILL will monitor these conditions in the days prior to the DGM start date and will be in regular communication with the DGM field team. Daily assessments of these conditions will also be made during the site safety briefings.

11. Potential Worker Hazards

Potential hazards include those associated with conducting field work in humid climates, active equipment staging areas, and densely wooded conditions. These and other specific hazards will be addressed in more detail in the project Activity Hazard Analysis, Health and Safety Plan, and during daily site safety briefings.

12. Handheld Geophysical Instrument

The primary handheld geophysical instrument to be used during non-DGM operations (such as MEC avoidance and placement of QC seeds) will be a White's XLT all-metals detector. The White's XLT all-metals detector is capable of identifying both ferrous and non-ferrous metals and is swept back and forth several inches above the ground surface. It will be used at the site to assist with MEC avoidance procedures during burial and placement of QC seed items to identify whether competing anomalies from subsurface metal (ferrous and non-ferrous) are present within 1 meter of an intended seed location. Audible tones and a digital display on the instrument indicate the presence of subsurface metal. The Schonstedt GA-52 handheld magnetometer may be used to supplement the White's XLT.

13. DGM Instrumentation

DGM will be conducted using the Geonics, Ltd., EM61-MK2. The EM61-MK2 has been presumptively selected based on existing site conditions, findings of the PA/SI and successful prior use of the EM61-MK2 elsewhere at MCIEAST–MCB CAMLEJ.

DGM will be performed along individual transects using a single-coil, person-portable EM61-MK2 unit. The footprint width of the single-coil EM61-MK2 (long axis perpendicular to walking direction) is approximately 3.3 feet (1 meter). DGM will be conducted along transects that correspond to approximately 10 percent coverage of the site (7.5 acres). The total length of transects would be approximately 99,573 linear feet (30,348 linear meters).

Location control for the EM61-MK2 data will be performed using fiducial positioning methods. It is assumed that sitewide conditions will not be conducive to the use of a global positioning system. Fiducial methods use a time-

marking procedure to determine the spatial location of the collected data. Using this approach, transects are established over the site to survey-grade accuracy (0.1 foot [3 centimeters]). Wooden stakes are placed at the beginning and end of each lane and at surveyed positions along each transect (every 80 feet [25 meters]). Transect establishment is performed by a North-Carolina-licensed professional land surveyor in advance of the DGM.

An operator walks down the lane while the data logger collects sensor readings with each revolution of the wheels if the EM61-MK2 is operated in this mode. As the center of the EM61-MK2 coils pass the starting, fiducial, and end points in the survey lane (that is, the surveyed wooden stake locations), the operator presses a button on the data logger that places a digital tag in the data file. By assuming the operator walked in a straight line between stakes and at a constant velocity, the location of each data point can be calculated in reference to the known survey stake locations.

The EM61-MK2 survey at Site UXO-22 will likely be conducted using wheel mode. However, the DGM subcontractor may elect to utilize two-person litter (that is, tandem) mode collection if ground surface conditions are determined not to be conducive to the use of the system on its standard wheels. In litter mode, the operator would collect data in automatic collection mode at a rate of 10 readings per second and insert fiducial markers in the data file as the center of the coil passed over a stake location.

14. Geophysical System Verification

DGM system validation will be performed for the EM61-MK2 using the Geophysical System Verification (GSV) process. The GSV is a physics-based, presumptively selected technology process in which signal strength and sensor performance are compared to known response curves of industry standard objects (ISOs) to verify DGM systems prior to and during site surveys. The GSV process is designed to perform initial verification of the proposed DGM system using an instrument verification strip followed by a blind seeding program for continued verification throughout the field operations. The GSV Work Plan is provided as **Appendix D** of the UFP-QAPP and provides additional details on the validation process for this site.

15. DGM Measurement Quality Objectives

The primary objective of the DGM activities at the subject site is to identify geophysical anomalies indicative of potential MEC or MPPEH. Measurement quality objectives (MQOs) particular to the DGM survey are provided in **Table 1**.

TABLE 1
Project Measurement Quality Objectives

MQO	Measurement Performance Criteria	Test Method
General System Function		
DGM System Munitions Detection. DGM system response is within industry standards for detection.	Response to ISO will not vary more than ±20 percent from known response for specific distance from sensors in static test.	Results of QC Test #4 (**Table 3**) will be compared to published response curves.
Repeatability. Repeatable and accurate data are being obtained from DGM system.	Response to ISO will not vary more than ±20 percent from known response for specific distance from sensors in static tests conducted at the beginning and end of each survey day. In addition, response of repeat line is comparable to original line data (qualitative determination).	Results of QC Test #4 (**Table 3**) will be evaluated quantitatively for compliance. Results of QC Test #5 (**Table 3**) will be qualitatively compared to results of original survey data.

TABLE 1
Project Measurement Quality Objectives

MQO	Measurement Performance Criteria	Test Method
DGM Surveys		
Data Density. Down line data density is sufficient to detect MEC items.	Over 98 percent of possible sensor readings are captured along a survey transect with a spacing of no greater than 0.7 foot (0.213 meter) between points. A data gap greater than 2 feet (0.61 meter) will not meet the MQO.	Results of DGM surveys will be quantitatively evaluated for compliance.
Data Positioning. Positioning of detected anomalies is accurate.	Anomaly locations representing QC seeds occur within a 3.3-foot (1-meter) radius of a point on the ground surface directly above the QC seed.	Anomalies selected will be compared with known (surveyed) seed item locations for compliance.
Data Handling		
Data must be delivered in a timely manner and in a useable format.	Data packages are completed and delivered to the CH2M HILL Project Geophysicist within schedule (3 days pre-processed; 5 days processed).	Evaluated based on actual delivery of data.

DGM System Munitions Detection

The MQO for munitions detection is to demonstrate that the EM61-MK2 system is capable of detecting munitions items within industry standards. This capability is demonstrated through a process in which signal strength and sensor performance are compared to validated industry values. For the EM61-MK2, this process involves demonstrating that the maximum amplitude response from an ISO falls within 20 percent of the predicted, published sensor response for that item (NRL, 2009). Once it has been demonstrated that the system responds comparably, a cross correlation of industry experience with detection of munitions items can be assumed. In other words, the depths and orientations of munitions items which the EM61-MK2 has been shown to be effective under test scenarios and other projects can be expected (NRL, 2008).

The spike test results (QC Test #4, **Table 3**) will determine whether the geophysical instrument is responding to within a specific threshold. In this test, the distance from the coil and orientation of the ISO can be strictly controlled in the field.

Repeatability

The MQO for DGM systems data repeatability is that the systems respond consistently from the beginning to the end of daily operation. For the EM61-MK2, this process involves demonstrating that the maximum amplitude response from an ISO falls within 20 percent of the predicted, published sensor response for that item at the beginning and end of each survey day.

In addition, as part of this MQO, repeat data profiles will also be collected and qualitatively compared to the original line data. This evaluation is a qualitative evaluation due to potential slight variations in paths traveled during survey line data and repeat line collection.

Repeatability will be evaluated by ensuring that, on a daily basis, the geophysical system being used passes QC Tests #4 and #5 in **Table 3**.

Data Density

The MQO for down line (along the survey transect) data density is to have sufficient data collected along each transect to detect MEC items and to minimize potential data gaps. The measurement performance criteria are that 98 percent or more of possible sensor readings are captured along each transect at distances of 0.7 foot (0.213 meter) or less and that no individual data gaps greater than 2 feet (0.61 meter) exist along a survey transect, unless the gap is associated with a surface obstruction. This spacing will be quantitatively evaluated in order to determine whether the DGM survey data used for anomaly selection meets this requirement.

Data Positioning

The MQO for data positioning accuracy is that positioning of detected anomalies is accurate enough to allow for effective reacquisition of the anomaly. The measurement performance criteria for this is that 100 percent of anomaly locations representing QC seeds are within a 3.3-foot (1-meter) radius of a point on the ground surface directly above the source of the anomaly associated with the seed item. An anomaly that is selected outside this radius will not be considered to be a successful detection of that item, unless the reasons for this occurrence can otherwise be explained.

Data Handling

The MQO for data handling is that pre-processed and final processed data must be delivered in a timely manner and in a useable format. During production surveys, the measurement performance criterion for data handling will require that "draft" (raw) data packages be completed and delivered to the CH2M HILL Project Geophysicist within 3 working days of data collection, and the final data packages must be delivered within 5 working days of data collection. Compliance will be evaluated based on the actual delivery of data.

16. Data Acquisition, Processing, and Reporting

16.1 Field Data Sheets

Field information will be logged and recorded in the Munitions Response Site Information Management System (MRSIMS). Field devices will be set up for use with MRSIMS and will include the following data entry fields:

- Site identification (ID)
- Survey Area ID (such as grid, grid block, transects, and so forth)
- Field team leader name
- Field team members' names
- Date of data collection
- Geophysical instrument used
- Positioning method used
- Instrument serial numbers
- Geophysical data file names
- Data collection rate (if applicable)
- Line numbers (including survey direction, fiducial locations, and start and end points, if applicable)
- Weather conditions
- Terrain conditions
- Cultural conditions
- Survey area sketch
- Associated QC data file names
- Miscellaneous field notes

16.2 Data Processing

Instrument-specific software will be used for initial data processing, and the output will be imported into Geosoft Oasis Montaj (Geosoft) for additional processing, graphical display, anomaly selection and QC evaluation. Types of processing will be system specific, but the general processing steps include, but may not be limited to the following:

- Positional offset correction
- Sensor bias, background leveling, and/or standardization adjustment
- Sensor drift removal
- Latency or lag correction

- Geophysical noise ID and removal (spatial, temporal, motional, and terrain induced)
- Contour level selection with background shading
- Digital filtering and enhancement (low pass, high pass, band pass, convolution, correlation, non-linear, and so forth)

16.3 Interpretation and Anomaly Selection

The data processor will use the following criteria, supplemented by site- and system-specific criteria established during instrument validation, for selecting geophysical anomalies that appear to be indicative of potential MEC or MPPEH:

- Maximum amplitude of the response with respect to local background conditions
- Decay curve characteristics
- Location of the response with respect to inaccessible areas, land features, cultural features, or utilities that bisect the transects
- Potential distortions in the response due to interference from manmade features that may be identified at the site during the DGM survey

16.4 Anomaly Locations

The data analysis process culminates in the creation of anomaly lists in MRSIMS format, an example of which is included as **Figure 2**. These lists can be opened using Microsoft Excel or standard text editors and include, at a minimum, the following information:

- Unique anomaly identifiers
- Survey area identifier
- Predicted location in Universal Transverse Mercator (UTM), North American Datum 1983 (NAD83) coordinates, in Easting (meters) and Northing (meters)
- Coordinates in site-specific UTM zone
- Anomaly type identifier (such as cultural debris, suspected utility, saturated response area, and so forth)
- Response amplitude
- Unit of response (millivolt [mV])

FIGURE 2
Example MRSIMS Anomaly List for EM61-MK2 Transect Data

ID	GRIDCELLID	X1	Y1	X2	Y2	X3	Y3	X4	Y4	TYPE	AMPLITUDE	UNITS
1	AA-00001	273474.60	3838895.60	0	0	0	0	0	0	1	20.20	mv
2	AA-00002	273473.80	3838893.20	0	0	0	0	0	0	1	8.04	mv
3	AA-00003	273471.00	3838886.00	0	0	0	0	0	0	1	8.85	mv
4	AA-00004	273469.00	3838881.60	0	0	0	0	0	0	1	11.85	mv
5	AA-00005	273462.60	3838867.60	0	0	0	0	0	0	1	27.94	mv

16.5 Anomaly Maps

DGM deliverables will include anomaly maps that contain, at a minimum, the following information:

- Client name
- Project name
- DGM subcontractor
- Map creator

- Map approver
- Date of map creation
- Map file name (full path and file extension)
- Map scale
- Survey area ID
- Contoured data with color scale
- Anomaly locations with unique ID numbers that match anomaly lists
- North arrow, legend, title block, and so forth

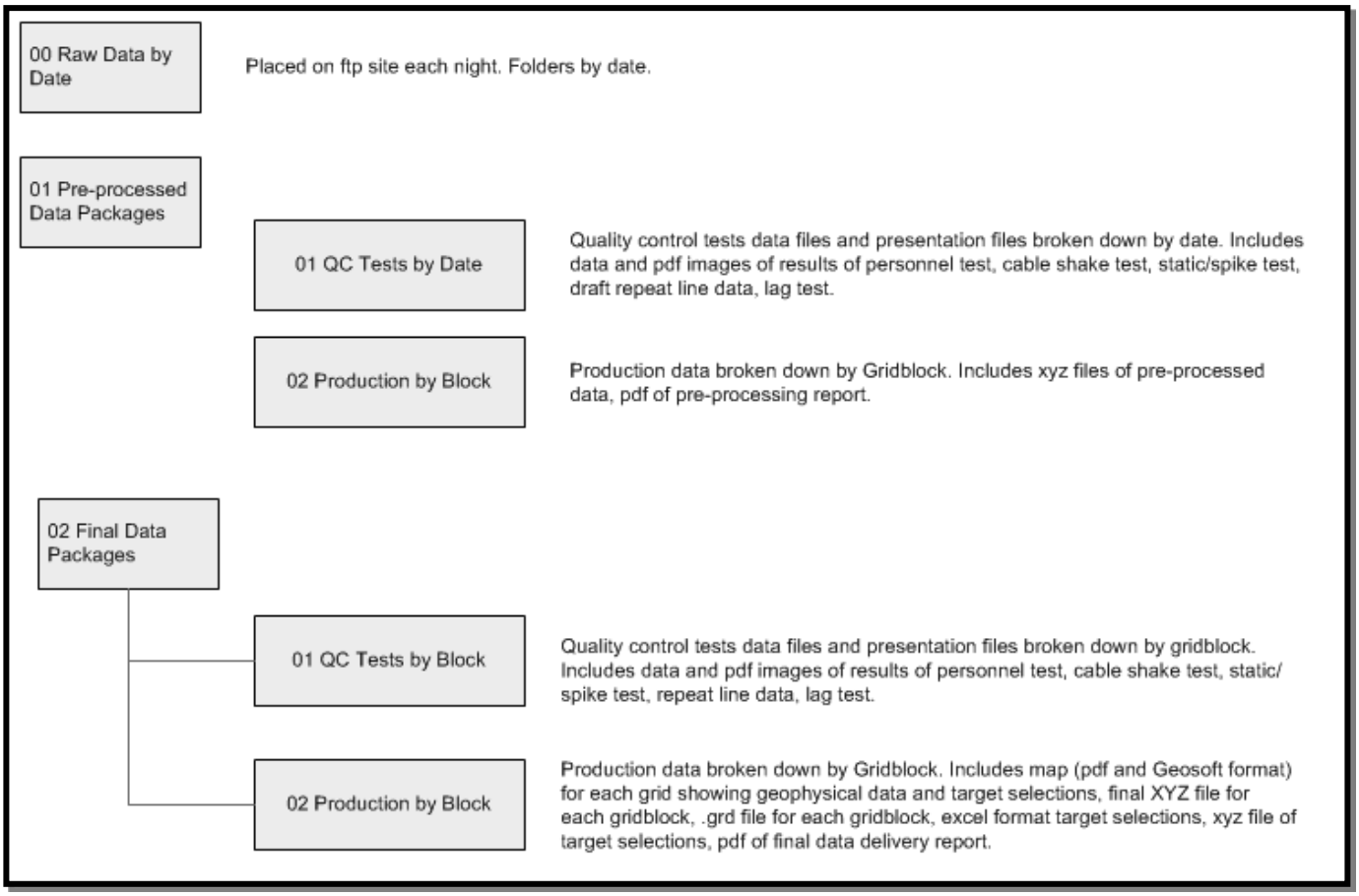
16.6 Records Management

Data files and deliverables will be available for quality assurance verification throughout the project in order to verify that field and data processing procedures are implemented according to this GIP. Raw data files, final processed data files, hard copies, and field notes will be maintained for the duration of the project.

16.7 Final Reports, Maps and Geophysical Data

Geophysical data will be provided via a Secure File Transfer Protocol (FTP) site maintained by CH2M HILL. Data will also be provided on DVD or CD with the final report. **Figure 3** presents the folder structure that will be used on the FTP site.

FIGURE 3
FTP Site Directory Structure



The deliverable requirements and data delivery schedule include the following:

- Raw data will be provided by the DGM subcontractor to CH2M HILL on a daily basis. Raw data are defined as data files stored on the instrument data logger, without any modification (or filtering) that changes the originally recorded values from the geophysical sensor and positional instrument (if applicable).
  - *File Format* - Raw data will be provided as American Standard Code for Information Interchange text format so the data files are viewable in text editing software. Proprietary binary format data will be directly converted to text format before delivery.
  - *Naming Convention* - Each delivered raw file will have an informative and unique name. Daily production raw files will have the acquisition date as part of the file name.
- Within 3 working days of data collection, the DGM subcontractor will provide CH2M HILL pre-processed data. The following applies to pre-processed data deliverables:
  - Pre-processed geophysical data, including QC tests, will be delivered in Geosoft database (GDB) and x,y,z format, readable by Geosoft.
  - QC test databases and Adobe Acrobat Portable Document Format (PDF) files containing images of QC test results will be provided and organized by date.
  - Pre-processed production data will be provided by designated survey area (such as grid, grid block, transect, and so forth).
  - An MRSIMS Pre-Processed Data Delivery Report in PDF will be provided with each designated survey area, which will contain field notes and pre-processing information. Information provided by the MRSIMS report is summarized in **Table 2**.
  - Pre-processed production data will be delivered in GDB or x,y,z format, and will include the following minimum channel information:
    - Easting (X) and Northing (Y) coordinates in site-specific UTM projection and in units of meters
    - Time (with precision to at least 0.1 second)
    - Raw geophysical data channels
    - Pre-processed geophysical data channels
- Within 5 days of data collection, the DGM subcontractor will provide CH2M HILL with final processed data. The following applies to the final processed data deliverables.
  - Processed geophysical data, including QC tests will be delivered in GDB or x,y,z format.
  - QC test databases and PDF files containing images of QC test results will be provided by survey area.
  - Processed production data will be provided by survey area.
  - An MRSIMS Final Data Delivery Report will be provided with each designated survey area, which will contain field notes and final processing information. Information provided by the MRSIMS report is summarized in **Table 2**.
  - Processed production databases will include the following minimum channel information:
    - Easting (X) and Northing (Y) coordinates in site-specific UTM projection (NAD83) and in units of meters
    - Time (with precision to at least 0.1 second)
    - Raw geophysical data channels
    - Pre-Processed geophysical data channels

- Processed geophysical data channels

– Final deliverables will include:

- Geosoft ".map" file for each grid
- PDF of Geosoft map for each grid
- Geosoft grid ".grd" file for survey area, showing gridded data from the channel used for anomaly selection
- Microsoft Excel (MRSIMS format) and Geosoft ".x,y,z" target files for each grid (or a text file stating "there were no selected targets in Grid X", if applicable)

Final processed filenames will include the grid or survey area name.

Within 60 days of data collection, the processed geophysical field data, final maps, and supporting geophysical interpretations will be provided by the DGM subcontractor.

TABLE 2
Processing Documentation Requirements

Information Type	Raw Data Delivery Report	Final Data Delivery Report	In File Headers
Site ID	X	X	X
Geophysical instrument used	X	X	X
Positioning method used	X	X	X
Instrument serial numbers (geophysical and positioning)	X	X	
Coordinate system and unit of measure	X	X	X
Grid ID (or other identifier of surveyed area)	X	X	X
Date of data collection	X	X	X
Raw data file names associated with delivery	X	X	
Processed data file names associated with delivery	X	X	
Name of Project Geophysicist	X	X	
Name of Site Geophysicist	X	X	
Name of data processor	X	X	
Data processing software used with version number	X	X	
Despiking method and details	X	X	
Sensor drift removal and details	X	X	
Latency/lag correction and details	X	X	
Sensor bias, background leveling, and/or standardization adjustment method and details		X	
PDF document showing graphical results of each field QC test	X	X	
Geophysical noise ID and removal (spatial, temporal, motional, and terrain induced) and details		X	
Other filtering/processing performed and details		X	
Gridding method		X	
Anomaly selection and decision criteria details		X	
Geosoft ".gdb" file for unit of survey being delivered (such as grid, grid block, or other area agreed upon with the client)		X	
Geosoft ".x,y,z" file for unit of survey being delivered (such as grid, grid block, or other area agreed upon with the client)		X	
Geosoft ".grd" file for unit of survey being delivered		X	

TABLE 2
Processing Documentation Requirements

Information Type	Raw Data Delivery Report	Final Data Delivery Report	In File Headers
Geosoft ".map" file for unit of survey being delivered		X	
PDF of Geosoft map for unit of survey being delivered		X	
Other processing comments		X	
Date data processing is completed	X	X	
Data delivery date	X	X	
Scanned copy of field notes and field mobile data collection device notes (if applicable)	X		

17. DGM Quality Control

The geophysical instruments will be field tested as part of the daily functional checks and as a means of reviewing system performance for compliance with the project MQOs. A description of each test, its acceptance criteria, and frequency is provided as follows and summarized in **Table 3**.

- **Equipment Warm-up (Test #1)**. The EM61-MK2 will be turned on for a minimum of 10 minutes prior to use. Equipment warm-up is performed each time the instrument is first turned on for the day or has been off for an extended period of time, thereby allowing the instrument to "cool down."
- **Personnel Test (Test #2).** This test checks the response of instruments to the personnel and their clothing/proximity to the system. On a daily basis, instrument sensors are checked for their response to the personnel operating the system, with response observed in the field for immediate corrective action. The personnel test is conducted at the beginning of the survey operations for each work day.
- **Vibration Test (Cable Shake) (Test #3)**. This test checks the response of instruments to vibration. On a daily basis, instrument sensors are checked for their response to vibrations through shaking the cables and observing the response in the field for immediate corrective action. The vibration test is conducted at the beginning of the survey operations for each work day.
- **Static Background and Static Spike (Test #4).** Static tests are performed by keeping the survey equipment stationary and positioning them within, or close to, the survey boundaries in an area relatively free of sources of metallic interference. Data are initially collected for a specific period (typically 1 minute) in order to measure background conditions. While keeping the instrument in a fixed position, data are recorded with a "spike" (ISO) placed at an accurately measured distance and orientation from the sensor. The purpose of the static test is to determine whether unusual levels of instrument or ambient noise exist. The static background and static spike test are conducted at the beginning and end of each survey operation as well as in between each designated survey area. For example, if the data are collected as blocks of transects (where one block comprises several transects), the static tests will also be conducted in between each block. Therefore, this test effectively "opens" and "closes" out the designated survey area.

  The ISO can be placed above or below the sensor so long as the distance is measured from the ISO center of mass to the center of the sensor. For the EM61-MK2, the center of the sensor corresponds to the center of the horizontal plane of the transmit coil (top of coil if item placed above coil, bottom of coil if item placed below), as illustrated on **Figure 4**.

FIGURE 4
Example Spike Test Setup

- **Repeat Data (Test #5):** This test is performed in order to evaluate repeatability of the data and will be performed between collection of a survey area (grid, grid block, set of transects, and so forth) after the initial survey over that area. Because of the intrinsic difficulty of following the exact same path for collecting repeat data, this test will be a qualitative comparison as opposed to quantitative.

TABLE 3
Geophysical Instrument Standardization Tests and Acceptance Criteria

Test	Test Description	Acceptance Criteria	Power On	Beginning of Day	Beginning and End of Day	Between Survey Areas	~2% of Daily Area Surveyed
1	Equipment Warm-up	Equipment specific (minimum 10 minutes)	X				
2	Personnel Test	Personnel, clothing, or other items should not result in EM61-MK2 Channel 2 data spikes greater than 2 mV from the mean		X			
3	Vibration Test (Cable Shake)	Data profile does not exhibit EM61-MK2 Channel 2 data spikes greater than 2 mV from the mean		X			
4	Static Background and Static Spike	±20 percent of standard item response, after background correction			X	X	
5	Repeat Data (Person Portable System)	Qualitative repeatability of response amplitude					X

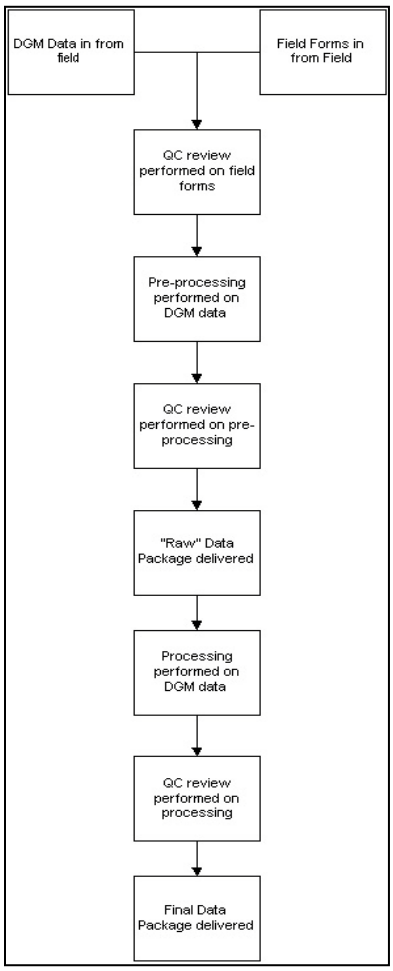
18. QC Seed Items

One QC seed item, consisting of a small ISO, will be buried within each 13,124 linear foot (4,000 linear meter) segment along the DGM transects. Details of the blind seeding program are provided in the GSV Work Plan, included as **Appendix D** of the UFP-QAPP.

19. QC of DGM Data and Deliverables

CH2M HILL will perform QC of geophysical data and data deliverables at each step of the processing path. **Figure 5** depicts the processing path and the QC steps performed. Data will not move to the next stage until they have passed each QC check.

FIGURE 5
Quality Control of DGM Data – Process Flow Path



20. Corrective Measures

Specific corrective measures are dependent on the type of geophysical equipment used. However, the following are the basic corrective measures to be followed in association with the DGM surveying:

- Replacement of sensors if they fail to meet functional check requirements.
- Re-collection of survey area units (grids) if seeded items are not identified (do not appear in the DGM data).
- Re-analysis of the DGM data if there is a failure to select a seed item as a target anomaly, but the item is clearly present in the DGM data.

21. Handheld Geophysical Instrument Quality Control

QC of the handheld geophysical instruments will be accomplished through daily functional checks prior to using them for field activities. Each instrument will be operated over a small metallic item buried close to the maximum detection depth determined for that item during instrument validation. If the instrument is not able to detect the item, it will be taken out of service until it can be repaired.

22. References

CH2M HILL. 2012. *Draft Preliminary Assessment/Site Inspection Report, Site UXO-22 – Former Munitions Disposal Area.* September.

Naval Research Laboratory (NRL). 2008. *Final Report for the Evaluation of UXO Detection Technology at the Standardized UXO Test Sites Aberdeen and Yuma Proving Grounds, Standardized UXO Technology Demonstration Site Program, SERDP. NRL/MR/6110-08-9155 (EM61-MK2 Response of Standard Munitions Items).* October.

NRL. 2009. *EM61-MK2 Response of Three Surrogates, NRL/MR/6110-09-9183*. March.

Appendix C
Geophysical System Verification Plan

Appendix C

Geophysical System Verification Plan
UXO-22 – Former Munitions Disposal Area

Marine Corps Installations East – Marine Corps Base Camp Lejeune, North Carolina

Contract Task Order WE54

August 2013

Prepared for

Department of the Navy
Naval Facilities Engineering Command
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Prepared by

Charlotte, North Carolina

Contents

Tables

Figures

Acronyms and Abbreviations

bgs	below ground surface
DGM	digital geophysical mapping
GIP	Geophysical Investigation Plan
GSV	Geophysical System Verification
ISO	industry standard object
IVS	instrument verification strip
MCIEAST–MCB CAMLEJ	Marine Corps Installations East–Marine Corps Base Camp Lejeune
MEC	munitions and explosives of concern
MPPEH	material potentially presenting an explosive hazard
MQO	Measurement Quality Objective
NRL	Naval Research Laboratory
QC	quality control
SOP	Standard Operating Procedure
UXO	Unexploded Ordnance

Geophysical System Verification Plan

The Geophysical System Verification (GSV) process is a physics-based, presumptively selected technology process in which signal strength and sensor performance are compared to known response curves of industry standard objects (ISOs) to verify digital geophysical mapping (DGM) systems prior to and during site surveys. The GSV process is designed to perform initial verification of the proposed DGM system using an instrument verification strip (IVS) followed by a blind seeding program for continued verification throughout the field operations.

The GSV process will be implemented for the EM61-MK2 survey to be conducted in support of a remedial investigation at Site Unexploded Ordnance (UXO) 22 – Former Munitions Disposal Area, at Marine Corps Installations East–Marine Corps Base Camp Lejeune (MCIEAST–MCB CAMLEJ) in Jacksonville, North Carolina.

1. Instrument Verification Strip

The initial phase of the GSV process is verification of the selected DGM system using an IVS. The IVS will be a land-based IVS.

1.1 Personnel and Qualifications

The following individuals will be involved in the IVS, GSV process, and DGM production survey:

- Project/Quality Control (QC) Geophysicist (CH2M HILL)
- Site Geophysicist (DGM Subcontractor)
- Field Geophysicist (DGM Subcontractor)
- Data Processor (DGM Subcontractor)
- UXO personnel (CH2M HILL)

Personnel involved in performance of the IVS and the production geophysical surveys will meet the following qualifications and have the following responsibilities throughout the duration of the survey:

- The **Project/QC Geophysicist** will have a degree in geophysics, geology, geological engineering, or a closely related field, and have a minimum of 5 years of directly related geophysical experience working at munitions and explosives of concern (MEC) and material potentially presenting an explosive hazard (MPPEH) sites. This individual will be responsible for constructing the IVS for use during DGM operations. This individual will also be capable of overseeing geophysical operations and support activities (such as land surveying and vegetation clearing), serving as the project team technical lead, performing QC of data as packages are delivered, and coordinating with the CH2M HILL Project Manager.
- The **Site Geophysicist** will have a degree in geophysics, geology, geological engineering, or a closely related field, and have a minimum of 2 years of directly related geophysical experience working at sites with MEC and MPPEH. This individual will serve as the subcontractor primary point of contact in the field, be capable of managing field staff, maintain geophysical equipment, perform in-field data quality checks, and make sure that field work and records management is completed in accordance with the project work plans and Health and Safety Plan.
- The **Field Geophysicist** will have a degree in geophysics, geology, geological engineering, or a closely related field and will have had training in the proper and safe operation of geophysical equipment. This individual will have at least 6 months of related geophysical experience working at MEC and MPPEH sites.
- The **Data Processor** will have a degree in geophysics, geology, geological engineering, or a closely related field, and will have at least 1 year of experience in processing geophysical data related to MEC and MPPEH projects.
- **UXO Personnel** will be responsible for overall daily site access and safety aspects of the project, compiling subcontractor health and safety documents, conducting daily safety briefings, and performing MEC

avoidance, as needed, in the field. Information on the specific qualifications for various UXO personnel support roles can be found in the Explosives Safety Submission.

1.2 Digital Geophysical Mapping System

DGM at Site UXO-22 will be conducted using the Geonics, Ltd., EM61-MK2. The EM61-MK2 has been presumptively selected based on existing site conditions, findings of the PA/SI, and successful prior use of the EM61-MK2 elsewhere at MCIEAST–MCB CAMLEJ.

The EM61-MK2 survey will be conducted along transects and will consist of a single coil, person-portable system to map geophysical anomalies that could potentially represent subsurface MEC or MPPEH. The EM61-MK2 survey at UXO-22 will likely be conducted using wheel mode. However, the DGM subcontractor may elect to utilize two-person litter (tandem) mode collection if ground surface conditions are determined not to be conducive to the use of the system on its standard wheels.

The QC program to be implemented for the DGM production survey is presented in the Geophysical Investigation Plan (GIP).

1.2.1 Geonics, Ltd., EM61-MK2

The EM61-MK2 is a high-resolution time-domain electromagnetic instrument designed to detect, with high spatial resolution, shallow ferrous and nonferrous metallic objects. The standard EM61-MK2 system consists of two air-cored, 1-meter by 0.5-meter (3.3 feet by 1.2 feet) coils, a digital data recorder, batteries, and processing electronics. The EM61-MK2's transmitter generates a pulsed primary magnetic field, which then induces eddy currents in nearby metallic objects. Each of the two spatially separated receiver coils measures these eddy currents. The EM61-MK2 offers the ability to measure the eddy currents at three distinct time intervals in the bottom coil or four intervals if no top coil measurements are recorded. Earlier time gates provide enhanced detection of smaller metallic objects. Secondary voltages induced in both coils are measured in millivolts. The arrangement of coils is such that there is a vertical separation of 40 centimeters (15.7 inches). To obtain as much information about the decay of the induced electromagnetic signal as possible, the top coil will not be used at this site as a data channel, and four bottom coil sensor channels will be recorded. Assuming accurate data positioning, target resolution of approximately 50 centimeters (20 inches) can be expected.

1.3 Positioning Method

Location control for the EM61-MK2 data will be performed using fiducial positioning methods. It is assumed that sitewide conditions will not be conducive to the use of a global positioning system. Fiducial methods use a time-marking procedure to determine the spatial location of the collected data. Using this approach, transects are established over the site to survey-grade accuracy (0.1 foot [3 centimeters]). Wooden stakes are placed at the beginning and end of each lane and at surveyed positions along each transect every 80 feet [25 meters]). Transect establishment is performed by a licensed professional land surveyor in advance of the DGM.

1.4 Location and Length of IVS

An area near the DGM survey area will be selected for the IVS. The exact location of the IVS will be finalized during the initial mobilization to the site. The IVS will be set up as a series of survey lanes, each with a minimum length of 20 meters (66 feet). **Section 1.5** provides additional details on the IVS set-up and construction.

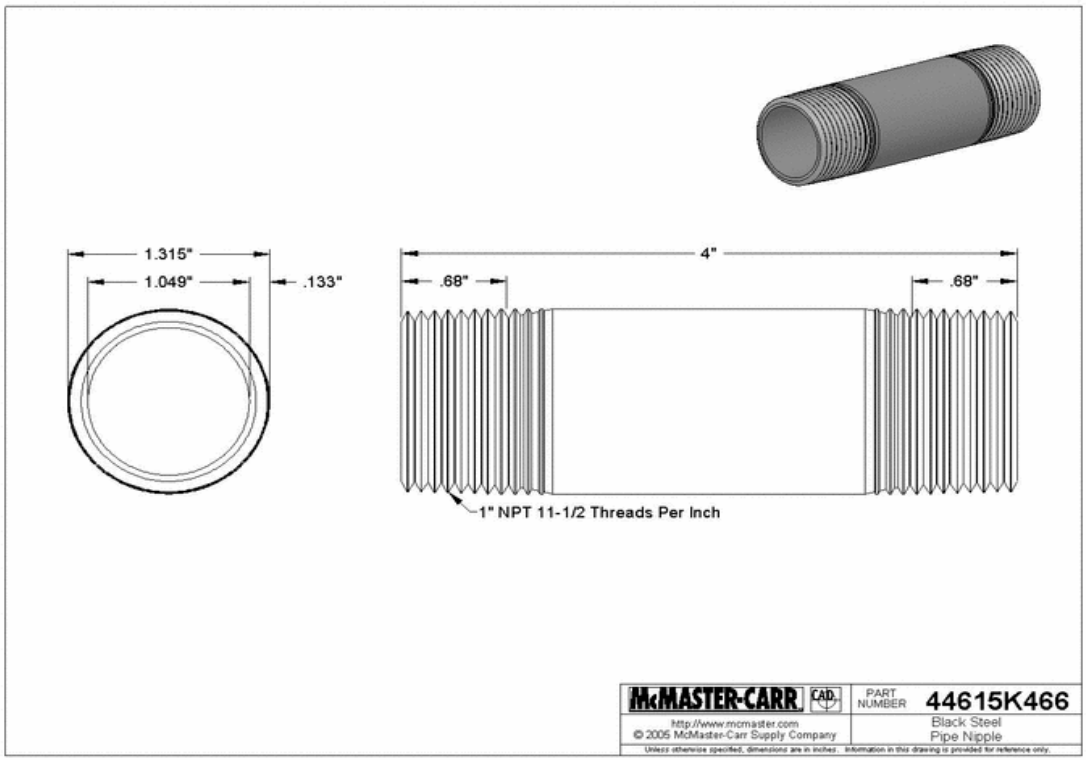
1.5 Industry Standard Objects

The ISOs (**Figure 1**) to be used in the IVS are 1-inch by 4-inch (2.54-centimeter by 10.16-centimeter) steel pipes (similar to McMaster-Carr part number 44615K466 [http://www.mcmaster.com/]) with the following specifications:

Shape: Straight Nipple, Threaded Both Ends
Schedule: 40

Pipe Size: 1 inch (1.315-inch outer diameter)
Length: 4 inches
Finish: Black Welded Steel.

FIGURE 1
Small ISO

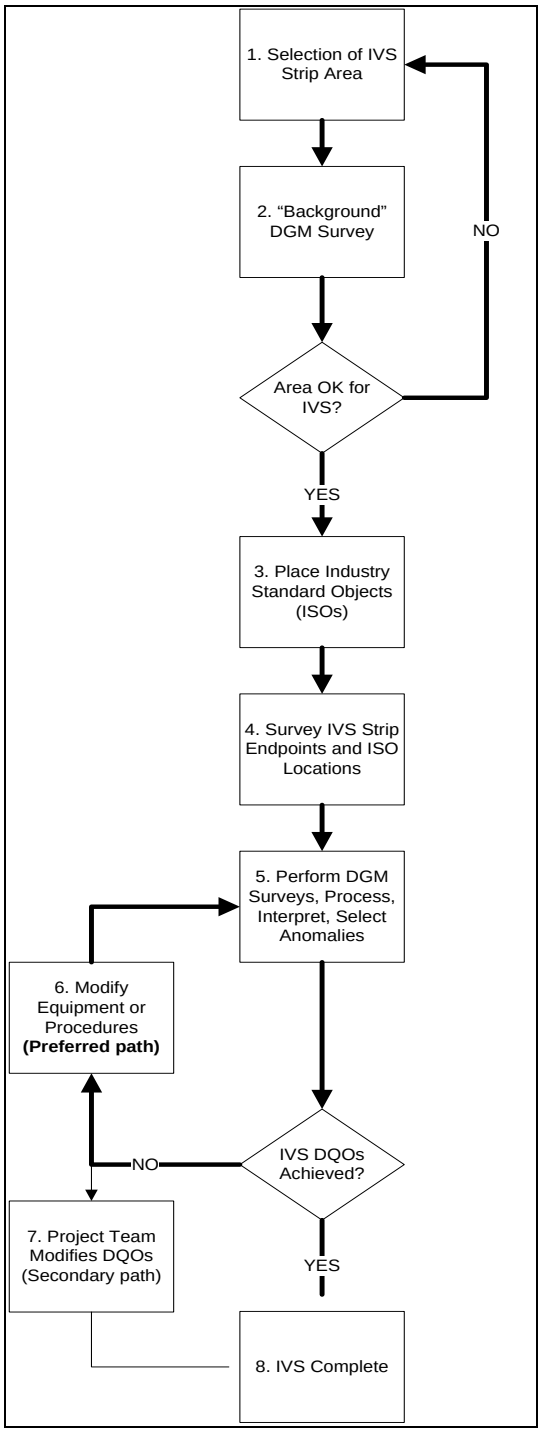


Instrument response curves for this ISO have been developed by the Naval Research Laboratory (NRL) demonstrating their standard response under their most favorable orientation (perpendicular to the EM61-MK2 instrument plane, that is, buried vertically in the ground surface) and least favorable orientation (parallel to the instrument plane, that is, buried horizontally and perpendicular to the direction of travel with the EM61-MK2) at a variety of distances from the instrument's bottom transmit/receive coil (NRL, 2009).

1.6 IVS Procedures

Figure 2 illustrates the overall IVS process and the procedures to be employed (numbered in accordance with the steps shown on **Figure 2**) during site work.

FIGURE 2
IVS Process



1. An IVS area will be selected with preference for the following (although none of the conditions are vital for IVS success):

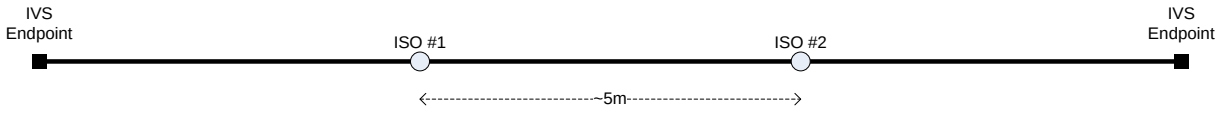
   - Terrain, geology, and vegetation similar to that of a majority of the DGM survey area
   - Geophysical noise conditions similar to those expected across the survey area

- Large enough site to accommodate all necessary IVS tests and equipment and for adequate spacing (at least 3 meters) of the ISO items to avoid ambiguities in data evaluation
- Readily accessible to project personnel
- Close proximity to the actual survey site (if not within the site)

2. A background DGM survey will be performed with the EM61-MK2. This step will help determine the appropriateness of the location (few existing anomalies), and will verify that ISOs are not seeded near existing anomalies. The data will be processed and provided to the CH2M HILL Project/QC Geophysicist for evaluation.

3. Once the IVS area is deemed suitable for use, (that is, free of significant subsurface anomalies or anomalies that are clearly identified so that they can be avoided during seeding), two small ISOs will be buried at depths below ground surface (bgs) of approximately 3 and 7 times the small ISO diameter (10 centimeters and 23 centimeters, respectively). The ISO will be placed in a plastic sealable bag, identified as inert, and labeled with the applicable contract number and CH2M HILL Project Manager contact information. These depths are intended to provide adequate signal to noise ratio for detecting the items. The generalized set-up of the seeded IVS transect is presented as **Figure 3**.

FIGURE 3
Generalized IVS Seeded Transect



Measurements of the item depths will be to the center of mass of each item. CH2M HILL onsite personnel will bury the ISOs using shovels to dig the holes to the appropriate depths for burial of the seed items in coordination with the Project/QC Geophysicist. The background survey data and anomaly avoidance techniques will be reviewed so that transect start and end stakes, and the seed items are not placed on top of or near existing anomalies. Personnel will bury the ISOs and record the emplacement depth and orientation.

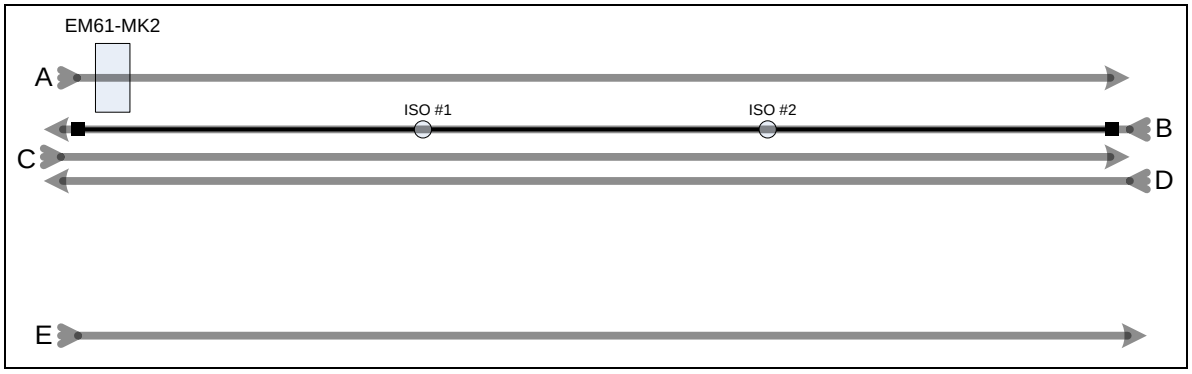
4. Either the land surveying or DGM subcontractor will record the locations of the IVS transect start and end locations as well as the buried ISOs. The holes will then be filled with soil and a vinyl-stem flag or wooden survey stake will be placed at each ISO location. If wooden stakes are used, they will not extend more than 1 foot above the ground surface so that the EM61-MK2 can easily pass over top of their locations.

5. A DGM survey using fiducial positioning methods will be performed over the IVS area, including transects as described in **Table 1** and indicated on **Figure 4**.

TABLE 1
IVS Transect Descriptions and Purpose

Transect	Description	Purpose
A	Offset by 0.75 meter	Demonstrate horizontal drop off of item response
B	Directly over center of strip (see **Figure 3**)	Verify response versus established response curves
C	Offset by 0.375 meter (half of intended lane separation) from center of strip	Demonstrate horizontal drop off of item response
D	Offset by 0.75 meter (on opposite side of strip from Transect A)	Demonstrate horizontal drop off of item response
E	Offset by ~3 meters from strip	Measure background noise

FIGURE 4
IVS Layout



The IVS will be established with Transects A and D at a spacing of 0.75 meter and Transect C at a spacing of 0.375 meter relative to the center strip. Details on the DGM production survey approach are provided in the GIP.

The IVS "5-line" survey data will be processed and interpreted by the DGM subcontractor's data processor and provided to the CH2M HILL Project/QC Geophysicist within 24 hours of completion of the IVS survey.

- If the initial Measurement Quality Objectives (MQOs) have not been met, the Project/QC Geophysicist will discuss with the Site Geophysicist whether modifications to instrumentation or procedures can be made to the DGM system in order to meet the MQOs.
- If the MQOs cannot be met, the Project/QC Geophysicist will meet with the project team to discuss potential resolutions (such as modification of an MQO) prior to completing the IVS and beginning the production survey.
- Once the system has been determined to meet the initial (or modified) MQOs, the IVS survey will be complete.

1.6 Measurement Quality Objectives

The MQOs for the IVS are presented in **Table 2**. The EM61-MK2 will not be used for site surveys until it is able to meet these MQOs or until the project team agrees on modifications to existing MQOs.

TABLE 2
IVS MQOs

MQO	Measurement Performance Criteria	Test Method During IVS
General System Verification		
DGM System Positioning. Accurate coordinates are obtained from kinematic (in-motion) DGM positioning systems.	Positional error of ISO seeds will not exceed 25 centimeters (9.8 inches) relative to surveyed locations.	Results of IVS DGM survey versus IVS seed locations will be evaluated for compliance.
DGM System Munitions Detection. DGM system response is within industry standards for detection.	Response to buried ISO will not vary more than ±20 percent from known response for specific distance from sensors in static test.	Results of IVS surveys over seed items in strip will be qualitatively reviewed for the person portable system. Results of static tests described in GIP will be quantitatively reviewed for compliance for each system used.
Data Handling		
Data must be delivered in a timely manner and in a useable format.	IVS survey results are delivered within 24 hours of completion of survey. Final processed packages delivered within 3 days.	Evaluate based on actual delivery of data

Additional MQOs for the production survey will be monitored through the blind seeding program and other QC tests, as discussed in the GIP. The IVS MQOs, measurement performance criteria, and test method to be used during the IVS are discussed in detail in the following subsections.

1.6.1 General System Verification

DGM System Positioning

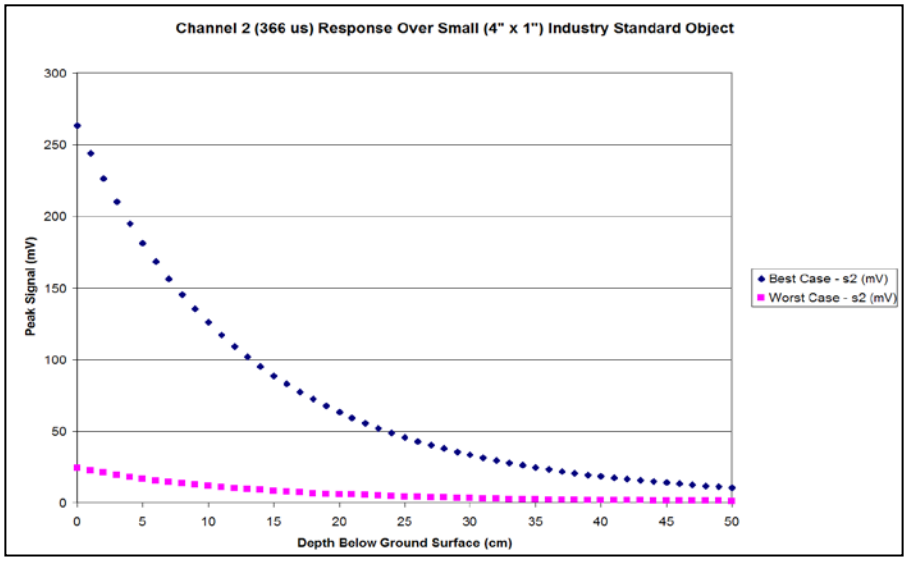
The MQO for DGM system positioning is that the resulting anomaly coordinates from the DGM survey from the seeded ISOs are at a sufficient accuracy to allow for appropriate relocation of MEC items for intrusive investigation. The measurement performance criterion for this is that the positional error at known IVS seed locations will not exceed 25 centimeters (9.8 inches).

DGM System Munitions Detection

The MQO for munitions detection is to demonstrate that the EM61-MK2 system is capable of detecting munitions items within industry standards. This process involves demonstrating that the maximum amplitude response from an ISO falls within 20 percent of the predicted, published sensor response for that item (NRL, 2009). Once it has been demonstrated that the system responds comparably, a cross correlation of industry experience with detection of munitions items can be assumed. In other words, the depths and orientations of munitions items which the EM61-MK2 has been shown to be effective under test scenarios and other projects can be expected (NRL, 2008). **Figure 5** presents the EM61-MK2 predicted responses for Channel 2 from a small ISO (NRL, 2009).

The static spike test results (discussed in the GIP) will determine whether the geophysical instrument is responding to within a specific threshold. In this test, the distance from the coil and orientation of the ISO can be strictly controlled in the field.

FIGURE 5
NRL (2009) Results for Small ISO Tested using EM61-MK2 Bottom Coil, Channel 2



Minor variations in the sensor height as it passes over the seeded item and slight variations in the path traveled down the IVS can affect the amplitude response received from the instrument. Therefore, the responses from the seeded ISOs in the IVS will be qualitatively evaluated for person portable systems. A determination that the geophysical instrument itself is responding within a specific threshold will be through the static spike test results.

1.6.2 Data Handling

The MQO for data handling is that data must be delivered in a timely manner and in a useable format. Due to the need for rapid feedback during IVS operations to effectively test potential DGM systems, the measurement

performance criterion for data handling during IVS activities will require that initial data be completed and delivered to the Project/QC Geophysicist within 24 hours of data collection. Processed data for the IVS will be delivered to the Project/QC Geophysicist within 3 working days of data collection. This MQO will be evaluated based on the actual delivery of data from the subcontractor.

1.7 IVS Data Analysis and Interpretation

The IVS survey data will be post-processed and analyzed per the data processing Standard Operating Procedures (SOPs) and in accordance with **Section 16** of the GIP.

1.8 DGM Quality Control

Achievement of the GSV MQOs will be verified by the CH2M HILL Project/QC Geophysicist. The selected IVS area, the process of emplacing the IVS items, and the survey locations will be verified through observation during the IVS set-up and execution. SOPs provided by the subcontractor prior to mobilization will be reviewed for compliance with the GIP and to confirm that equipment functional checks are established and utilized.

The QC tests discussed in detail in **Section 17** of the GIP will be performed as part of the GSV and IVS procedure for the DGM systems being utilized.

1.9 IVS Data Evaluation and Reporting

The Project/QC geophysicist will evaluate the IVS survey results and QC tests as the last step in the validation process.

2. Blind Seeding

As a continuation of the GSV process and ongoing verification of the EM61-MK2 system operation, one QC seed item, consisting of a small ISO, will be buried within each 13,124 linear foot (4,000 linear meter) segment along the DGM transects. .

2.1 Seed Placement

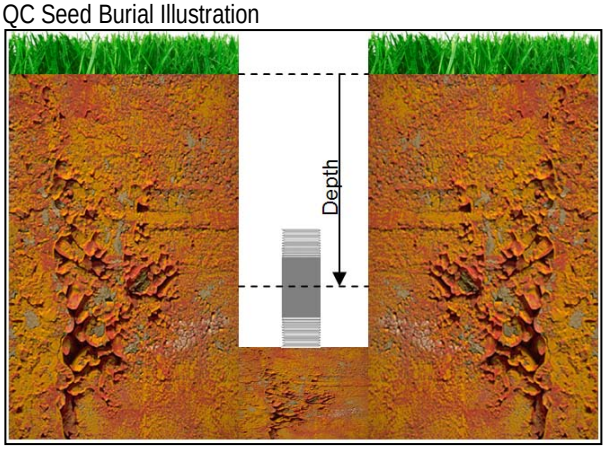
CH2M HILL will bury seed items with a vertical orientation and at a depth of6 inches (15.2 centimeters) bgs. Depth will be measured to the center of mass of the item, as illustrated on **Figure 6**. Depths will be recorded in field notes.

UXO personnel will utilize a White's XLT all metals detector to clear the locations of each proposed seed location in order to avoid placing the seed near a subsurface metallic object. The following also applies to the placement of the seed items:

- UXO personnel will clear the proposed seed locations to make sure there are no potentially competing subsurface anomalies that may impact the ability to successfully detect the seed items with the geophysical instruments.
- Seeds will not be placed within a 1 meter (3.3 feet) radius of a surveyor stake, tree, or other physical obstruction.
- Holes will be dug by UXO personnel or under their direct supervision.
- The seed items will be left exposed after emplacement so that the land surveying subcontractor can record the locations of the items. The surveyor will record the location of the center of the seed items.
- The seed items will be labeled with the CH2M HILL Project Manager name and contact information, as well as the applicable contract number for the project. They will be placed in a sealed plastic bag or securely wrapped in non-metallic material to prevent groundwater from obscuring the labels.
- Once surveyed, the seeds will be carefully covered with soil so as to not disturb their orientation.

- No physical markers will be left in place to denote the locations of the seed items.
- The locations of the seed items will be provided to the CH2M HILL Project/QC Geophysicist.

FIGURE 6
QC Seed Burial Illustration



2.2 Validation

During review of the delivered data packages, the Project/QC geophysicist will overlay the locations of the blind seeds to observe whether the munitions detection and positioning MQOs are met. Should an issue be detected (such as a data trend indicating a MQO limit is being approached) or a MQO is not met, a comprehensive Root-Cause Analysis will be performed and a corrective action determined.

3. Reporting

Results of the GSV process will be included in a report prepared by CH2M HILL. The report will include a summary of the IVS operations and initial validation, an as-built map of the IVS plot, and discussion of the IVS and blind seeding program results.

4. References

Naval Research Laboratory (NRL). 2008. *Final Report for the Evaluation of UXO Detection Technology at the Standardized UXO Test Sites Aberdeen and Yuma Proving Grounds, Standardized UXO Technology Demonstration Site Program, SERDP. NRL/MR/6110-08-9155 (EM61-MK2 Response of Standard Munitions Items).* October.

NRL. 2009. *EM61-MK2 Response of Three Surrogates, NRL/MR/6110-09-9183*. March.